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THESIS

PERFORMANCE OF MULTIPLE, ANGLED NOZZLES
WITH SHORT MIXING STACK EDUCTOR SYSTEMS

by

Charles Carver Davis

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Thesis Advisor: P.F. Pucci

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Performance of Multiple, Angled Nozzles with Short Mixing Stack Eductor Systems

by

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ABSTRACT

Cold flow tests were conducted on a four-nozzle gas eductor system to evaluate the feasibility of reducing mixing stack lengths by the application of angled primary flow nozzles. Three short mixing stacks with length to diameter ratios of 1.75, 1.5, and 1.25 were tested using a set of straight nozzles and a series of angled nozzles having tilt angles of 10, 15, 20, and 22.5 degrees. The nozzles were constructed with an area of primary flow to area of mixing stack ratio of 2.5. Pumping coefficients, mixing stack pressure distributions, flow changes, exit velocity profiles, and back pressures were used to evaluate the various mixing stack length and angled nozzle combinations. A preferred combination was obtained, which, when compared with a longer mixing stack with a length to diameter ratio of 2.5 using straight nozzles, showed equal pumping coefficients and comparable mixing stack pressure distributions while actually improving the mixing. Back pressure increases for the preferred combination of short mixing stack and angled nozzles were slightly greater than for the longer mixing stack with straight nozzles.

TABLE OF CONTENTS

LIST OF TABLES

NOTE: Due to the number of tables involved, individual table numbers and titles will not be given in this listing. Each table listed below represents a series of tables relating to the particular topic given.

LIST OF FIGURES

NOTE: The following figures are a series of performance plots for the different angled nozzle combinations and mixing stacks. The figure number for each individual plot will not be listed, but can be found in the same sequence order following the first plot for a given nozzle and mixing stack combination.

PERFORMANCE PLOTS FOR THE L/D = 1.75 MIXING STACK

PERFORMANCE PLOTS FOR THE L/D = 1.25 MIXING STACK

NOTE: The following figures are a series of summary comparison plots of pumping coefficients for the combinations listed above.

NOMENCLATURE

English Letter Symbols

A	Area (in.^{2})
c	Sonic velocity (ft/sec)
C	Coefficient of discharge
D	Diameter (in.)
F_a	Thermal expansion factor
F_{fr}	Wall skin-friction force (lbf)
g_c	Proportionality factor in Newton's Second Law (g_c = 32.174 lbm-ft/lbf-sec^2)
h	Enthalpy (Btu/lbm)
k	Ratio of specific heats
L	Length (in.)
P	Pressure (in. H_2O)
P_a	Atmospheric pressure (in. Hg)
P_v	Velocity head (in. H_2O)
PMS	Static pressure along the length of the mixing stack (in. H_2O)
R	Gas constant for air (R = 53.34 ft-lbf/lbm-R)
s	Entropy (Btu/lbm-R)
S	Distance from primary nozzle exit plane to mixing stack entrance plane (in.)
T	Absolute temperature (R)

u	Internal energy (Btu/lbm)
U	Velocity (ft/sec)
v	Specific volume (ft^3/lbm)
W	Mass flow rate (lbm/sec)
Y	Expansion factor

Dimensionless Groupings

A*	Ratio of secondary flow area to primary flow area
AR	Area ratio
f	Friction factor
K	Flow coefficient
K_e	Kinetic energy correction factor
K_m	Momentum correction factor at the mixing stack exit
K_p	Momentum correction factor at the primary nozzle exit
L/D	Ratio of mixing stack length to mixing stack diameter
M	Mach number
p*	Pressure coefficient
PMS*	Mixing stack pressure coefficient
Re	Reynolds number
S/D	Standoff; ratio of distance from primary nozzle exit plane to entrance plane of the mixing stack (S) to the diameter of the mixing stack (D)

T^*	Absolute temperature ratio of the secondary flow to primary flow
T_t^* , TT*	Absolute temperature ratio of the tertiary flow to primary flow
W_s^* , W*	Secondary mass flow rate to primary mass flow rate ratio
W_t^* , WT*	Tertiary mass flow to primary mass flow rate ratio
ρ^*	Induced flow density to primary flow density ratio

Greek Letter Symbols

μ	Absolute viscosity (lbf-sec/ft^2)
ρ	Density (lbm/ft^3)
θ	Primary nozzle tilt angle
ϕ	Primary nozzle rotation angle
ψ	Nozzle base plate rotation angle
β	Ratio of ASME long radius metering nozzle throat diameter to inlet diameter

Subscripts

0	Section within secondary air plenum
1	Section at primary nozzle exit
2	Section at mixing stack exit
f	Film or wall cooling
m	Mixed flow or mixing stack
or	Orifice

p	Primary
s	Secondary
t	Tertiary (Cooling)
u	Uptake
w	Mixing stack inside wall

<u>Computer Tabulated Data</u>

DPOR	Pressure differntial across the orifice (in. H_2O)
POR	Static pressure at the orifice (in. H_2O)
PSEC	Static pressure at the mixing stack entrance (in. H_2O)
PTER	Static pressure in the tertiary air plenum (in. H_2O)
PUPT	Static pressure in the uptake (in. H_2O)
TAMB	Ambient air temperature (°F)
TOR	Air temperature at the orifice (°F)
TUPT	Temperature of air in the uptake (°F)
UM	Average velocity in the mixing stack (ft/sec)
UP	Primary flow velocity at primary nozzle
UUPT	Primary flow velocity in uptake (ft/sec)
UPT MACH	Uptake Mach number
UE	Average velocity at the mixing stack exit (ft/sec)
WM	Mass flow rate from mixing stack (lbm/sec)
WP	Mass flow from primary nozzles (lbm/sec)
WS	SEcondary mass flow rate (lbm/sec)
WT	Tertiary mass flow rate (lbm/sec)

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I. INTRODUCTION

Gas turbine applications in marine propulsion and in auxiliary systems have increased dramatically over the last decade. Their high horsepower to specific weight, increasingly competitive specific fuel consumption, and lower watchstander and maintenance requirements have made them extremely attractive for advanced marine designs such as hydrofoil, planing hulls, SWATH, and SES craft as well as more conventional monohull vessels. Consequently, special considerations must be given to the applications of gas turbines due to their particualr air breathing and exhausting characteristics.

A. NATURE OF THE PROBLEM

Gas turbines require large amounts of cooling air in addition to the quantity needed for combustion, therefore air-fuel ratios are generally three to five times those of conventional steam and diesel power plants of comparable size. The exhaust gases are also roughly twice as hot as for these conventional power plants. In general, gas turbine power plants produce considerably larger volumes of higher temperature exhaust or stack gases. These exhaust gases contribute to greater thermal and corrosive damage in the electrical equipment located on masts near the exhaust stream, hot gas corrosion of masts and superstructures in the hot gas wake, possible aircraft control problems for helicopter

operation in or near the exhaust stream, and a significantly greater infrared radiation signature due to both the high volumetric and temperature exhaust plumes as well as the hotter external surfaces on the exhaust stacks.

B. POSSIBLE SOLUTIONS

The volume and temperatures of exhaust gases are fairly well fixed by gas turbine size, power loading, and current gas turbine technology; consequently, other means must be employed to counter the problems associated with gas turbine systems.

Waste heat boilers or heat exchangers do reduce the exhaust gas temperatures and offer increased economy by recovering thermal energy which would otherwise be lost to the atmosphere Unfortunately, such systems require considerable space and tend to generate back pressures which lower gas turbine performance. Fouling is also an ever present problem. Waste heat boilers have been tried on auxiliary power systems with limited success and research is still underway in this area.

Water injection systems are another possible solution. They are active systems which require moving parts, injection metering and control equipment, and large amounts of water, Costs and maintenance thus become problems.

One of the most promising systems for combatting the overall problem is the gas eductor. By using properly dimensioned primary flow nozzles for the exhaust gases and mixing stacks, secondary or ambient air is induced. The turbulent mixing

reduces the overall exhaust temperatures, back pressures are minimized when compared with other systems, and resultant negative pressures along the mixing stack walls can be utilized to further induce a tertiary ambient cooling flow through ports in the mixing stack. If the mixing stack is then shrouded, this tertiary flow creates a film cooled outer stack while adding additional thermal mixing of the exhaust gases. The straight, unshrouded mixing stack system is presently in operation on several naval vessels. An additional positive feature of gas eductor systems is that they can be used in conjunction with either of the other two possible solutions with minor modifications.

C. GAS EDUCTOR RESEARCH AT THE NAVAL POSTGRADUATE SCHOOL

This thesis is a further extension of research conducted by Ellin [Ref. 1], Moss [Ref. 2], Lemke and Staehli [Ref. 3], Shaw [Ref. 4], and Ryan [Ref. 5] on the cold flow eductor model testing facility. Hill's research [Ref. 6] on the hot flow eductor model testing facility should also be mentioned as it verified that cold flow modeling procedures correlated extremely well with actual hot flow data on geometrically similar eductor configurations. This correlation allows utilization of the more time and cost effective cold flow facility to develop optimum designs and configurations which can then be verified with actual hot flow testing.

Ellin initiated the early work by constructing an eductor model testing facility consisting of an uptake, centrifugal

compressor, primary flow nozzle section, mixing stack, and a means to control and measure the primary and secondary air flows. See Figures 1 and 2 for the general test model layout. The primary air flow in the test facility represents the gas turbine's hot exhaust gases. The secondary air flow is ambient air induced into the mixing stack by the primary air flow and gas eductor concept. From Ellin's study of multiple vice single nozzle flow systems, it was determined that four primary flow nozzles were preferable to either three or five nozzle systems. Ellin also determined that the nozzle length had little if any effect on the overall performance of the gas eductor system. He then verified the independence of the one-dimensional gas eductor modelling correlation parameters used on the flow rate or Mach number. His research showed that one-dimensional analysis provided good correlation of data for Mach numbers from 50 to 145 percent of the design Mach number of 0.064.

Moss's research initially consisted of reverification of the one-dimensional analysis. Moss then explored the effects of the stand-off distance, which is the distance from the primary nozzle exit plane to the entrance plane on the mixing stack. For non-dimensional analysis, the stand-off distance is divided by the mixing stack diameter to give the S/D ratio. Moss determined that eductor pumping was maximized when the stand-off distance was one-half the mixing stack diameter (S/D = 0.5). An independent investigation conducted by

Harrell [Ref. 7] confirmed Moss's results. Moss then explored the effects of adding a conical transition piece to the entrance of the mixing stack to enhance eductor pumping. Experiments showed that the entrance transition piece actually slightly degraded overall performance.

Lemke and Staehli investigated overall eductor system's performance for different geometric configurations of the mixing stack and for different area ratios of the primary nozzles. The area ratio for nozzles is defined as the cross sectional area of the mixing stack divided by the total cross sectional area of the primary nozzles. Their work showed that decreasing the nozzle area ratio from 3.0 to 2.5 decreased the back pressures but also decreased the eductor's pumping coefficient. Lemke and Staehli then investigated the effects of adding a solid diffusor, a two ring diffusor, and a three-ring diffusor to the exit region of the mixing stack. These tests showed a decrease in uptake back pressure and an improvement in the eductor's pumping capacity. They then added slotted ports to the mixing stack to induce tertiary air. Their results showed significant air flow occurred through the ports. A shroud was then added, and tests showed that the shroud did not degrade either the pumping or mixing characteristics of the eductor but that it did provide an effective thermal shield around the mixing stack. Their final configuration was a ported mixing stack with a shroud and ring diffusors at the exit. The 3.0 area ratio nozzles and a standoff ratio of 0.5

were used in several of their investigations with mixing stack length to diameter ratios of 2.5 and 3.0.

The object of this thesis is directed toward reducing the length of the mixing stack by investigating the effects of angled primary flow nozzles on a four-nozzle gas eductor system. The results of investigations by Moss and Lemke and Staehli on the longer L/D ratios of 3.0 and 2.5 thus serve as a data base for comparing the effects of both straight and angled primary flow nozzles on the shorter mixing stack L/D ratios of 1.75, 1.5, and 1.25 used in this investigation.

D. EVALUATION OF GAS EDUCTOR SYSTEM PERFORMANCE

Evaluation of the gas eductor system performance is measured in the following areas: the amount of secondary air flow induced by the primary air flow; the amount of tertiary air flow induced; the degree of mixing of the primary and induced flows within the mixing stack; the amount of uptake back pressure impressed upon the gas turbine exhaust by the eductor system; and the amount of wall cooling air available to reduce the exterior stack temperatures. Because of the angled primary flow nozzles, several new parameters were defined to assist in evluating the gas eductor system's performance. The new parameters include the primary nozzle tilt angle, primary nozzle rotation angle, and the nozzle base plate rotation angle. These parameters will be discussed in further sections of this report.

II. MAJOR DIMENSIONLESS PARAMETERS

This investigation is an extension of earlier work conducted by Ellin, Moss, and Lemke and Staehli [Ref. 1,2,3] and utilizes the same one-dimensional analysis technique to model the gas eductor system. The more detailed analysis is given in Appendix A. In conducting this analysis, four major dimensionless parameters are used. The first three are used to evaluate the eductor's pumping performance, and the last is used to evaluate the static pressure distribution along the length of the mixing stack. The four major dimensionless paratemers are:

$$P^* = \frac{\dfrac{P_a - P_{os}}{\rho_s}}{\dfrac{U_p^2}{2g_c}}$$

a pressure coefficient which compares the pumped head, $(P_a - P_{os})/\rho_s$, to the driving head, $U_p^2/2g_c$, of the primary flow

$$W^* = \frac{W_s}{W_p}$$

a flow rate ratio of secondary to primary mass flow rates

$$T^* = \frac{T_s}{T_p}$$

an absolute temperature ratio of secondary to primary air temperatures

$$PMS^* = \frac{\dfrac{PMS}{\rho_s}}{\dfrac{U_p^2}{2g_c}}$$

a pressure coefficient which compares the pumped head, PMS/ρ_s, to the driving head, $U_p^2/2g_c$, where PMS is the static pressure along the mixing stack.

III. EXPERIMENTAL CORRELATION

For the geometries and flow rates investigated, it was confirmed by Ellin and Moss [Ref. 1 and 2] that a satisfactory correlation of the variables P*, T*, and W* takes the form

$$\frac{P^*}{T^*} = f(W^*T^{*n}) \qquad (1)$$

where the exponent 'n' was determined to be equal to 0.44. The details of the determination of n = 0.44 as the correlating exponent for the geometric parameters of the gas eductor model being tested is given in Reference [1]. To obtain a gas eductor model's pumping characteristic curve, the experimental data is correlated and analyzed by using equation (1), that is, P*/T* is plotted as a function of $W^*T^{*0.44}$. This correlation is used to predict the open-to-the-environment operating point for the gas eductor model. Variations in the model's geometry will change the pumping ability, which can be evalated by the plot of equation (1). For ease of discussion, $W^*T^{*0.44}$ will be referred to as the pumping coefficient in this report. Similarly, $WT^{**}TT^{*0.44}$ will be referred to as the film cooling or tertiary pumping coefficient.

IV. MODEL GEOMETRIES

The four-nozzle gas eductor system investigated in this report made use of a single primary flow uptake, a single cluster of four primary flow angled nozzles held in a rotatable base plate, and a straight, unshrouded, unported mixing stack without diffusor rings at the mixing stack exit.

A. MIXING STACK CONFIGURATION AND GEOMETRIES

The primary thrust of this research was to study the effects of angled nozzles on the performance of shorter mixing stacks. Three short mixing stacks were manufactured from nominally 12 inch OD and 11.7 inch ID PVC agriculture water irrigation pipe. The mixing stacks were constructed with L/D ratios of 1.75, 1.5, and 1.25. The L/D ratio of 1.75 was chosen as a starting point since baseline data was available for the primary nozzle area ratio of 2.5 from Lemke and Staehlis research [Ref. 3]. Their major research was concerned with longer mixing stacks with L/D ratios of 2.5 and 3.0, which could also be used to compare with the shorter mixing stacks. Pressure taps were installed in the shorter mixing stacks at 0.25 X/D increments (2.93 inch spacing) to provide more data points for evaluating the mixing stack pressure distribution. 0.5 X/D spacing had been used on the longer mixing stacks. The dimsnsions for the three mixing stacks are provided in

Figure 6, and pictures of the mixing stack can be found in Figures 8 and 9.

B. ANGLED PRIMARY FLOW NOZZLE CONFIGURATION AND GEOMETRIES

The angled nozzle concept was chosen as the starting point for reducing the overall length of the mixing stacks by enhancing the mixing process. The nozzles were to have a constant cross section while having the ability to be inclined and rotated about a centerline axis. Several new parameters were defined for designing, manufacturing, and measuring the angled nozzles. The first parameter is the nozzle tilt angle, θ, which is the cant angle measured from the centerline of a straight nozzle to the centerline of an angled nozzle. The nozzle rotation angle, ϕ, is the angle that the nozzle is rotated inward toward the mixing stack centerline from a perpendicular to a radial line from the base plate center to the center of the nozzle. It is difficult to picture these definitions, and Figures 10 and 13 provide a clearer visualization for the nozzle configurations.

Several concepts were explored while attempting to design an easily manufactured and measurable angled nozzle. The most practical solution was to take a section of straight piping, cut it in two sections on a line mitered one half of the overall tilt angle desired, rotating the two sections 180 degrees, and then joining them together for the final tilt angle. The nozzles used in actual testing were manufactured from clear, cast acrylic pipe with a nominal 4.0 inch OD and

3.625 inch ID which had to be machined to 3.7 inches ID to give a nozzle area ratio of 2.5 for the four nozzles in each group. The nozzles were also machined 0.5 inches up from the base to properly mate with the recesses in the nozzle base plate. The edges where the two nozzle sections were joined were faired in to reduce abrupt flow direction changes both inside and outside the individual nozzles. Four nozzles for each configuration were constructed for nozzle tilt angles of 10 degrees, 15 degrees, 20 degrees, and 22.5 degrees as well as a set of straight nozzles for baseline data and mixing stack alignment purposes. The angled nozzles were dimensioned so that the intersection of their centerline and exit plane corresponded with the length of the straight nozzles used by Ellin, Moss, and Lemke and Staehli, thus establishing a common measurement for the standoff distance. This allowed alignment of the nozzles and mixing stack and setting the S/D ratio with the straight nozzles and not having to completely realign the system everytime the angled nozzles were changed. The nozzles and base plate were constructed of similar material with tight tolerances where they mated together. Thermal expansion was essentially equal for both components, and the friction provided was sufficient for holding the nozzles in place while allowing rotation angle changes. This feature allowed deletion of O-rings for seals and some form of mechanical locking device. The angled nozzle geometries are given in Figure 10, and photographs of the nozzles are found in Figures 11, 12, and 16.

C. NOZZLE BASE PLATE CONFIGURATION AND GEOMETRIES

The nozzle base plate was constructed from acrylic plexiglass flat stock. Four recess holes were machined to accept the nozzles, and they were in turn machined to a 0.5 inch radius on the underside to present a smooth flow entrance region for the nozzles. The outer edge of the base plate was machined so that the whole base plate fit inside a matching aluminum base ring. The construction was such that the base plate could be rotated within the ring, primary flow pressure kept the two concentric surfaces mated which eliminated seals, and the base plate could not be ejected from the uptake by the considerable dynamic pressures associated with the high velocity primary air flow. Four symetrically located locking cams allowed the base plate and installed nozzles to be locked in place. This was required for alignment procedures and prevent rotation during initial start-up. Once the system was warmed up to operating conditions, the difference between thermal expansion factors for the ring and base plate allowed sufficient expansion to make the use of the locking cams unneccessary. In fact, rotation of the base plate could be difficult when the system was fully warmed up, and a dry teflon lubricant was used to help overcome this problem.

A third new parameter was need for the base plate's ability to be rotated. The base plate rotation angle, ψ, is hereby defined as the angle of base plate rotation measured from the 90 degree point on the uptake transition piece as

depicted in Figure 13. This parameter serves to give a general indication of the flow directions within the mixing stack due to the angled nozzles. The base plate's geometry and dimensions are given in Figure 14, and photographs can be seen in Figures 15 and 16.

V. EXPERIMENTAL FACILITY

Air is supplied to the primary nozzles by means of a centrifugal compressor and associated ducting schematically illustrated in Figure 1. The mixing stack configuration being tested is placed inside an air plenum containing an airtight partition so that two separate air flows, secondary and tertiary, may be measured. The air plenem facilitates the accurate measurement of secondary and tertiary air flows by using ASME long radius flow nozzles.

A. PRIMARY AIR SYSTEM

The circled numbers found in this section refer to locations on Figure 1. The primary air ducting is constructed of 16-gage steel with 0.635 cm (0.25 in) thick steel flanges. The ducting sections were assembled using 0.635 cm (0.25 in) bolts with air drying silicone rubber seals between the flanges of adjacent sections. Entrance to the inlet ducting 1 is from the exterior of the building through a 91.44 cm (3.0 ft) square to a 30.48 cm (1.0 ft) square reducer, each side of which has the curvature of a quarter ellipse. A transition section 2 then changes the 30.48 cm (1.0 ft) square section to a 35.31 cm (13.90 in) diameter circular section 3 . This circular section runs approximately 9.14 m (30 ft) to the centrifugal compressor inlet.

A standard ASME square edged orifice (4) is located 15 diameters downstream of the entrance reducer and 11 diameters upstream of the centrifugal compressor inlet, thus insuring stability of flow at both the orifice and compressor inlet. Piezometer rings (5) are located one diameter upstream and one-half diameter downstream of the orifice. The duct section also contains a thermocouple just downstream of the orifice. Primary flow is measured by means of the standard ASME square edged orifice designed to the specifications given in the ASME power test code [Ref. 8]. The 17.55 cm (6.902 in) diameter orifice used was constructed out of 304 stainless steel 0.635 cm (0.25 in) thick. The inside diameter of the duct at the orifice is 35.31 cm (13.90 in) which yields a beta (β = d/D) of 0.497. The orifice diameter was chosen to give the best performance in regard to pressure drop and pressure loss across the orifice for the primary air flow rate used (1.71 Kg/sec (3.77 lbm/sec)).

The centrifugal compressor (7) used to provide primary air to the system is a Spencer Turbo Compressor, catalogue number 25100-H, rated at 6000 cfm at 2.5 psi back pressure. The compressor is driven by a three phase, 440 volt, 100 horsepower motor.

A manually operated sliding plate variable orifice (6) was designed to constrict the flow symmetrically and facilitate fine control of the primary air flow. During operation, the butterfly valve (8) , located at the compressor's

discharge, provided adequate regulation of primary air flow, eliminating the necessity of using the sliding plate valve. The sliding plate valve was positioned in the wide-open position for all data runs.

On the compressor discharge side, immediately downstream of the butterfly valve, is a round to square transition (9) followed by a 90 degree elbow (10) and a straight section duct (11). All ducting to this point is considered part of the fixed primary air supply system. A transition section (12) is fitted to this last square section which reduces the duct cross section to a circular section 29.72 cm (11.17 in) in diameter. This circular ducting tapers down to a diameter of 26.30 cm (11.5 in) to provide the primary air inlet to the eductor system being tested. The transition is located far enough upstream of the model to insure that the flow reaching the model is fully developed.

B. SECONDARY AIR PLENUM

The secondary air plenum, shown in Figures 1, 2, and 3, is constructed of 1.905 cm (0.75 in) plywood and measures 1.22 m by 1.22 m by 1.88 m (4. ft by 4 ft by 6.17 ft). It serves as an enclosure that can contain all or only part of the eductor model and still allow the exit plane of the mixing stack to protrude. The purpose of the secondary air plenum is to serve as a boundary through which secondary air for the eductor system must flow. Long radius ASME flow nozzles,

designed in accordance with ASME power test codes [Ref. 8] and constructed of fiberglass, penetrate the secondary air plenum, thereby providing the sole means for metering the secondary air reaching the eductor as shown in Figures 1 through 4. Appendix D of reference [1] outlines the design and construction of the secondary air flow nozzles. By measuring the temperature of the air entering and the pressure differential across the ASME flow nozzles, the mass flow rate of secondary air can be determined. Flexibility is provided in measurement of the mass flow rate of secondary air by employing flow nozzles with three different throat diameters: 20.32 cm (8 in), 10.16 cm (4.in), and 5.08 cm (2 in). By using a combination of flow nozzles, a wide variety of secondary cross sectional areas can be obtained.

A secondary air flow straightener, shown in Figures 1, 2, and 4, consisting of a double screen is installed 1.22 m (4 ft) from the open end of the secondary air plenum, between the ASME long radius nozzles and the primary air flow nozzles. The purpose of the straightener is to reduce any swirl effect that could result when only a small secondary air flow area exists.

C. TERTIARY AIR PLENUM

The tertiary air plenum, shown in Figures 1, 2, 8 and 9, is constructed of 1.90 cm (0.75 in) plywood and measure 1.22 m by 1.22 m by 1.22 m (4 ft by 4 ft by 4 ft). It serves as an enclosure that completely surrounds the mixing stack and allows

the exit and entrance regions to protrude. An airtight rubber diaphragm type seal, schematically illustrated in Figure 2, is located at each end of the enclosure. This allows measurement of a tertiary air flow independent of the secondary air flow. Tertiary air flow is measured with the use of long radius ASME flow nozzles designed in accordance with ASME test codes [Ref. 8] and constructed of fiberglass. These nozzles are located so that they penetrate the airtight tertiary air plenum, thereby providing the sole means for metering the tertiary air reaching the eductor. By measuring the temperature of the air entering and the pressure differential across the ASME flow nozzles, the mass flow rate of tertiary air can easily be obtained. Flexibility in measuring the tertiary flow is provided by employing different size flow nozzles: two of 20.32 cm (8 in) throat diameter, three of 10.16 cm (4 in) throat diameter, and two of 5.08 cm (2 in) throat diameter. By using various combinations of these flow nozzles, a wide variety of tertiary cross section flow areas can be obtained.

The interior of the tertiary air plenum is pictured in Figures 8 and 9. The stand which holds the mixing stack can be seen mounted inside the plenum.

D. ALIGNMENT

The alignment of the mixing stack with the primary air flow nozzles is accomplished by using two round alignment plugs, a nozzle alignment plate, and a 0.75 inch OD steel

alignment bar. The two circular alignment plugs are inserted into opposite ends of the mixing stack, and the nozzle alignment plate is then carefully inserted over the straight nozzles. The steel alignment bar is then inserted through the centerline holes in the alignment plugs and brought up to the centerline hole in the nozzle alignment plate. The three axis mounting stand, pictured in Figure 8, is adjusted until the alignment bar can be fully inserted into the nozzle alignment plate and recess in the nozzle base plate without difficulty.

E. INSTRUMENTATION

Pressure taps for measuring gage pressures are located inside the primary air uptakes just prior to the primary nozzles, inside the secondary air plenum, inside the tertiary air plenum, and at various points on the model. A variety of manometers, pictured in Figure 18, were used to indicate the pressure differentials. A schematic representation of the pressure measuring instrumentation is illustrated in Figures 17 and 19. Monitoring of each of the various pressures was facilitated by the use of a scanivalve and a multiple valve manifold. The scanivalve was used to select the pressure tap to be read, while the multiple value manifold allowed selection of the optimum manometer for the pressure being recorded. A vent was included in the multiple valve manifold which provided a means of venting the manometers between pressure readings. When taking readings of the pressure distribution in the mixing stack, it was necessary to manually change the

tubing from one end of the manometer to the other in order to get the positive pressure readings. The valve manifold provided a selection of a 15.24 cm (6.0 in) inclined water manometer, a 5.08 cm (2.0 in) inclined water manometer, and a 1.27 cm (0.5 in) inclined oil manometer (specific gravity 0.827). In addition, the following dedicated manometers were used in the system: a 50.80 cm (20 in) single column water manometer connected to the primary air flow just prior to the primary nozzles, a 1.27 cm (50 in) U-tube water manometer with each leg connected to a piezometric ring on either side of the orifice plate in the air inlet duct, and a 2.55 cm (1.0 in) inclined water manometer connected to the upstream piezometric ring.

Primary air temperatures, measured at the orifice outlet and just prior to the primary nozzles, are measured with copper-constantan thermocouples. The thermocouples are in assemblies manufactured by Honeywell under the trade name Megapak. Polyvinyl covered 20 gage copper-constantan extension wire is used to connect the thermocouples to an Omega Digital Thermometer, Model Number 2176A, which provided a digital display of the measured temperatures in degrees Fahrenheit or Centigrade. Due to the longer data runs involved with this thesis, another thermocouple was added to measure the secondary/tertiary ambient air temperature to provide more timely data. The mercury-glass thermometer was retained for comparison purposes.

Velocity traverse profiles at the mixing stack exit plane are obtained by using a pitot tube mounted in a revised velocity traverse bar. The entire assembly was rebuilt to provide increased stability and support for the pitot tube which had to reach up to 30 inches into the tertiary plenum to record velocity profiles on the short, L/D = 1.25 mixing stack. The tram bar was also equipped with a new distance measuring system to increase accuracy and lower data acquisition time. The pitot tube is used in conjunction with the 50.80 cm (20 in) single column water manometer vice the 6.0 inch inclined water manometer, mainly due to the higher pressures involved with the shorter mixing stacks and the greater pressure fluctuations. Threaded studs were used to locate the velocity traverse bar and pitot tube assembly for both the horizontal and diagonal velocity profiles. Four nuts kept the system in place and provided rapid changeover from one profile to the other. The assembly can be seen in Figure 8.

VI. EXPERIMENTAL METHOD

Evaluation of the eductor model requires the experimental determination of pressure differentials across the ASME long radius flow nozzles, temperatures of primary and induced air flows, internal mixing stack pressure distributions, and mixing stack exit velocity profiles from pitot tube pressure readings. In addition, base plate rotation angles are used to get a general understanding of the flow patterns within the mixing stack. These experimentally determined quantities are then reduced with the aid of a computer to obain pumping coefficients, induced air flow rates, pressure distributions and flow distributions in the mixing stack, and mixing stack velocity profiles at the exit plane of the mixing stack. The performance characteristics of the eductor due to the different nozzle geometric configurations are then evaluated graphically by use of computer generated plots. The plots also help to determine the model's relative effectiveness and problem areas which may not be apparent when reviewing raw and processed data.

The following sections address the individual performance criteria used to evaluate the eductor and nozzle combinations. Circled numbers refer to regions located on the representative plots used in the evaluation process.

A. PUMPING COEFFICIENT

The secondary pumping coefficient and the tertiary pumping coefficients provied a basis for analyzing the eductor's pumping capability. Nozzle combination changes alter the eductor's pumping performance, and the pumping coefficient is one of the major criteria for comparing various nozzles as well as any changes to the mixing stack such as shrouding, porting, diffusor rings, L/D ratios, and S/D ratios. The pumping coefficient(s) for the model should correspond to the coefficients for the shipboard gas eductor system. At the operating point, the eductor is exposed to no restrictions in the secondary or tertiary air flows. In the model, this is simulated by completely opening the air plenums to the environment. Unfortunately, at this condition, the secondary and/or tertiary air flow rates can not be measured. The eductor model's characteristics must then be established by extrapolating the measured pumping coefficients to the desired operating point.

The data for this extrapolation is established by varying the associated induced air flow rate, either secondary or tertiary, from zero to its maximum measurable rate. These rates are determined by sequentially opening the ASME flow nozzles mounted in the appropriate plenum and recording the pressure drop across the nozzles. Values for nozzle cross-section areas, pressure drops, induced flow air temperatures, and barometric pressures are then used to calculate the

dimensionless parameters P^*/T^* and $W^*T^{*0.44}$ as described in Appendix A. The dimensionless parameters are then plotted as illustrated in Figure 20. The data point (1) corresponds to closing all ASME flow nozzles. Data points in region (2) corresponds to opening most of the ASME flow nozzles and the final data point corresponds to opening all flow nozzles, plenum doors, or other plenum penetrations available. Early data runs attempted to gain more accuracy in this region by taking more data. Unfortunately, the pressure drop across the nozzles is so critical in this region that any error or fluctuations causes considerable data scatter. Such points were deleted from the finished plots contained in this thesis. In theory, there should be no pressure inside the plenum at the operating point except for ambient pressure. In reality there is always some small negative pressure present. The data points in region (3) provide the most consistent and accurate data. Extrapolation of the pumping characteristics curve to intersect the zero P^*/T^* or PT^*/TT^* abscissa locates the appropriate operating point for the eductor model configuration.

B. INDUCED AIR FLOWS

Secondary and tertiary air flows are induced flows. In this thesis, only the secondary air flow was of concern although both flows were written into the documentation and computer programs.

The secondary air flow is the amount of air induced by the primary nozzles which is mixed within the mixing stack with primary air to reduce the exhaust gas temperature.

C. PRESSURE DISTRIBUTION IN THE MIXING STACK

The axial pressure distribution in the mixing stack is obtained by taking static pressure reading from pressure taps attached to the stack in two rows. In the cold flow test facility, the mixing stack is located horizontally in the tertiary plenum. The first row is located on the top of the mixing stack, and the second row is offset 45 degrees from the first row as shown in Figures 6 and 7. The pressure taps were located 0.25 mixing stack diameters apart. Actual locations are given in Figure 6. The dimensionless mixing stack pressure term, PMS*, as previously mentioned in Section II and as derived in Appendix A, is then calculated from the static pressure data. PMS* is plotted versus X/D pressure tap locations to obtain the mixing stack pressure distribution. A sample distribution is shown in Figure 21. Region 1 is located at the entrance of the mixing stack, and it has the highest negative pressure readings for each stack. The early tests confirmed that there were definite limits on the amount of nozzle tilt and rotation before the primary flow started to interfere with the secondary flow in this region. Pressures near region 2, located toward the exit of the stack, tend to possess lower potential for inducing tertiary flow when compared to pressures near region 1 . Pressures located

at region 3 , located just prior to the exit of the mixing stack may actually be positive, or above ambient pressure. In the sample plot, the data point at region 2 has very little potential for inducing tertiary flow, and the data point at region 3 is positive which would hinder tertiary flow. It is therefore desirable to look for nozzles combinations which produce pressure distributions remaining below the zero PMS* line on the plot and as low down on the PMS* axis as possible.

D. MIXING STACK ROTATION ANGLE

The straight nozzles produce a symmetric flow consisting of four peak and four null pressure areas along the axis of the mixing stack. Pressure taps at position 'A' normally could be used to record the peaks while the position 'B' taps could be used to record the lower pressure regions or nulls. With introduction of the angled nozzles, the flow became swirled. A rotatable base plate was used to scan the entire circumference of the mixing stack at each L/D position and thereby obtain a better record of the varying axial pressure distribution. This allowed the peaks and troughs to be rotated to the stationary pressure taps for data acquisition. The base plate rotation angle, ψ, is recorded for each pressure tap position, and when plotted, provides a rough indication of the flow pattern variations. Region 1 in Figure 22 corresponds to the rotation angle needed to align the peak position 'A' reading with the pressure tap and is always the

actual angle recorded. The other data points were actually rotated 90 degrees for plotting purposes. The data in Figure 22 is fairly stable and indicates little twisting of the primary flow. Region 2 often showed a considerable change in flow direction as did region 3 . Again, the plots of this data only serves as a general indication of flow directions, which were in agreement with observations of tufts of string used to follow the flow paths on each run.

Tests were conducted early in the research to determine the sensitivity of the rotation angles. Results showed that changes as small as one degree of rotation could cause large pressure changes while at other times the base plate could be rotated 30 degrees without any pressure changes.

E. *VELOCITY TRAVERSES*

The velocity traverses are generated by moving the pitot tube in measured increments across the horizontal and diagonal lines as indicated in Figure 7. Stagnation pressure readings are read from the 20 inch manometer and combined with data taken for the pumping coefficients to calculate mixing stack exit velocities in units of feet/second. Computer generated two-dimensional plots of the velocity traverses can then be used to get indications of mixing, wall effects, and primary flow core formation.

The sample horizontal velocity profile shown in Figure 23 shows two, essentially primary flow peaks at regions 2 and 4 . Regions 1 and 5 are essentially secondary

induced flows and show some wall efforts. Region 3 should be symmetrically located at the center of the stack, however misalignment of the base plate may cause the center trough to appear displaced. Region 6 should have data points which overlap data points on the diagonal velocity plot.

The sample diagonal velocity profile shown in Figure 24 shows noticeable peaks and troughs. The peaks at regions 1 and 7 are the primary nozzle flows which have not been rotated inward enough to get better mixing. The peaks at 3 and 5 correspond to peaks 2 and 4 on the horizontal velocity profile. Region 4 should be at the same point as region 3 in the horizontal profile, and serves as a quick indication of rotation angle misalignment. Region 8 data points should be the same as those in the other profile. This region also is observed for coring effects when the nozzles have excessive tilt and rotation.

The dashed lines in both sample profiles are just rough indications of what a fully developed turbulent flow should look like. With the short mixing stacks, this will never be achieved, but the goal is to select nozzle combinations which can give generally flat overall profiles as an indication of enhanced mixing. Sharp peaks and troughs should therefore be avoided or minimized. The comparison plots of the two profiles serves to determine data accuracy, the interaction of the flows, and base plate misalignment which can seriously skew the profiles.

Due to the flow rotation created by the angled primary nozzles, the nozzles base plate had to be rotated on a trial-and-error basis to bring the primary flows into alignment with the pitot tube for the diagonal velocity traverse profile. This setting of the nozzle base plate was kept intact for the horizontal velocity profile. Alignment procedures called for obtaining a peak pressure reading on the diagonal traverse, adjusting the sliding scale on the velocity traverse bar and moving the bar until a symmetric profile was achieved, and then verifying the base plate rotation.

VII. DISCUSSION OF EXPERIMENTAL RESULTS

Major components for the straight geometry mixing stacks were relocated, overhauled, and installed while the components and computer software for the angled primary flow nozzles were being developed. The data reduction process and basic cold flow test facility components were then verified by taking a series of tests with a set of straight nozzles used by Lemke and Staehli [Ref. 3]. This set of nozzles had inner diameters of 3.38 inches and an area ratio of 3.0. This early data is not presented in this report, but it correlated extremely well with Lemke and Staehli's results. These tests confirmed that higher pumping coefficients on the order of 0.75 could be obtained if you are willing to suffer the considerably higher, approximately 2.5 inches of water higher back pressure and higher nozzle exhaust velocities when compared to straight nozzles having an inner diameter of 3.70 inches and area ratio of 2.5 on the same mixing stack with an L/D ratio of 1.75. The test results for the 3.7 inch ID and AR = 2.5 straight nozzles on a mixing stack with L/D = 1.75 and S/D = 0.5 are given in Tables 2 through 2.3, and the plots are given in Figures 25 through 25.4. This data compared extremely well with Lemke and Staehli's results as listed in Table V.c of Reference [3] and is plotted in Figure 25. This data served as a baseline for evaluating the angled nozzles with the same L/D, S/D, and AR ratios for the early data runs.

The angled nozzle combinations in the remainder of this discussion will appear as 15/10 for example, where the 15 is the nozzle tilt angle, θ, and the 10 is the nozzle rotation angle, ϕ. Due to the large number of plots and tables involved, references to individual plots and tables for the various nozzle combinations will not normally be made except by references to the series of data for that particular combination. The notation FT 15/8, for example, will be used to indicate that the plots are located in the Figure 15 series and that the data is located in the Table 8 series for the nozzle combination specified. The summary tables, Tables 1.1, 1.2, and 1.3, and the summary plots given in Figures 75 through 81 may also prove to be of great value when reading this discussion. The mini-plots given with the tabulated data are also quite helpful when reviewing data. The abbreviations MSD for mixing stack pressure distribution, PCD for pumping coefficient, and VTD for velocity traverse distribution will also be used in this discussion and in the summary of tabulated data tables. Unless specifically mentioned otherwise, the S/D ratio of 0.5 was used throughout these investigations.

The first set of angled nozzles chosen for testing were the 15 degree tilt series. These nozzles were near the middle of the 10, 15, 20, and 22.5 degree tilt angle nozzles available, and it was hoped that by testing nozzles on either side of them that a trend would quickly develop which could possibly reduce the amount of testing necessary. The four sets of

angled nozzles could be rotated from zero to between 25 and 45 degrees depending on the amount of tilt angle involved. The rotation angles can be adjusted in one degree increments which made the number of nozzles combinations available for testing extremely large. This was further compounded by the requirement to test these combinations on three different L/D ratio mixing stacks. It was decided that rotation angles in 10 degree increments would be used to help alleviate the number of runs possible while still developing a thorough data base.

A. L/D = 1.75 (LONG STACK) RESULTS

Although the L/D = 1.75 mixing stack was the longest mixing stack tested, it is still approximately only two-thirds the L/D ratio of stacks involved in past research as well as those in actual use on several naval vessels. The 15/00 combination was tested first with results given in the FT 30/7 series. the pumping coefficient for the straight nozzles was 0.54 and the 15/00 nozzles increased this to 0.57. The MSD profile was worse and indicated a positive PMS* pressure value near the L/D = 1.5 pressure tap. The VTD profile showed that the primary flow was predominant along the walls for the diagonal profile while the horizonatal profile was nice and flat. Unfortunately, this first angled nozzle data run pointed out that it would take about 2.5 hours to get a complete set of acceptable data.

The PCD data was fairly easy to take, however, the angled nozzles had to be rotated with the base plate to get accurate MSD data. The alignment of the velocity profile traverse system to get the profiles centered was hard enough, but the base plate had to be rotated to the optimum position to get an unskewed profile. Consequently, there was a lot of trial-and-error adjustment required while taking the MSD and VTD data.

Tests were rerun on the 15/00 nozzles to determine if the base plate could be fixed at the zero point, rotated to the peak pressure at position 'A' and left there, or had to be rotated for both maximum and minimum pressure readings along the mixing stack. The results are given in the FT 31/8, FT 32/9, and FT 33/10 series. It was determined that the rotation angles served only as a general indication of flow directions and was not as important as the pressure readings along the stack. The results also showed that rotating the peak pressure to the top pressure taps gave fairly accurate minimum readings on the diagonal pressure taps without further rotation of the base plate. The next data run for the 15/10 nozzles showed that not only may one miss the minimum reading, one might miss any positive pressures as well when using this approach. Consequently, the MSD procedure that evolved was to rotate the base plate to get a maximum negative or positive pressure reading at the top pressure taps, record the reading and the rotation angle, rotate the base plate for a minimum reading on the diagonal taps, compare the two angles,

and record the average of the two. This did help reduce the run time down to two hours, and nothing was found to reduce the time involved obtaining the velocity profiles. The semi-automated data system in its present configuration would have actually increased the run times for the particular geometries associated with this research.

The next tests were conducted on the 15/10 and 15/20 nozzle combinations, and results are given in the FT 34/11 and FT 35/12 series. The pumping coefficients were both in the 0.59 range with the 15/20 nozzles being just slightly better. Both had similar MSD profiles with one slightly positive PMS* reading near the stack exit. The 15/20 combination had the less positive PMS* reading of these two nozzle combinations, and its VTD profile was also slightly better than the 15/10 combinations.

The 15/30 tests given in FT 39/16 showed a pumping coefficient of 0.55 which was lower than either of the 15/10 or 15/20 combinations. The MSD profile showed some improvement, but the positive PMS* reading still existed in the same region. The diagonal VTD profile was excellent, but the horizonatal profile showed onset of primary flow coring.

The next approach was to split the difference and try a 15/25 combination to see if there was a maximum pumping coefficient in the combination region. Results are given in FT 36/13 and the pumping coefficient fell to 0.58. The positive PMS* reading was lower than in the 15/20 data, but the

VTD profiles were slightly worse for thermal mixing. This same nozzle combination was then used for testing S/D ratios of 0.4 and 0.25 to determine the effect of reducing the stand-off distance. Moss in Reference [2] had shown that the optimum S/D ratio for the straight primary nozzles was 0.5. Results are given in the FT 37/14 and FT 38/15 series. The S/D = 0.4 run showed a slightly better pumping coefficient of 0.585 when compared with the S/D = 0.5 pumping coefficient of 0.58. The positive PMS* reading near the mixing stack exit was intermittently negative and finally stayed negative as the data run progressed. Unfortunately, the VTD profiles were poorer for the S/D = 0.4 ratio. The S/D = 0.25 pumping coefficient fell off to 0.55, the MSD profile was better than the other two S/D rations, and the VTD profile was much worse than either the S/D = 0.5 or S/D = 0.4 profiles. In comparing the results, it was determined that the angled nozzles generally behaved as staight nozzles as far as stand-off distance ratios were concerned and the results followed the curve generated by Moss. Each change of the S/D ratio requires realignment of the mixing stack which can take a considerably amount of time, the results correlated with Moss's findings, and further comparison of S/D ratios for the two shorter mixing stacks was ruled out.

Full data runs were then conducted on 20/10 and 20/20 nozzle combinations with the results being given in the FT 40/17 and FT 41/18 series. Although they had pumping

coefficients below the 15/20 nozzle combination, they both exhibited improved VTD profiles. The MSD profiles both had more positive PMS* readings and were generally poorer than for the 15/20 combination. The hoped for trend was becoming clear, however the data acquisition time for a full set of data on every nozzle combination would have precluded testing on the other two mixing stacks. It was felt that the angled nozzles did make shorter mixing stacks possible, but that the MSD profiles were substandard for the stack tested. Testing was needed on the shorter stacks to determine if the MSD profiles would be improved while maintaining or improving the pumping coefficients.

A careful review of evaluation procedures disclosed that all parameters have to be analyzed, but that the pumping coefficient was slightly predominant. The tests so far had shown that any amount of nozzle tilt and rotation improved the pumping coefficient over that of the straight nozzles. To establish a broader data base while still being able to test the shorter stacks, run times had to be reduced still further. It was decided to take partial data runs for pumping coefficient data over the remainder of the nozzles followed by full data runs on nozzle combinations with the better pumping coefficients.

The PCD data only procedure was then conducted on the 20/30 and all of the 10 degree and 22.5 degree tilt angle nozzles. The plots and tabulated data for these various combinations are provided in this report; however, the summary

of tabulated data in Tables 1.1 and 1.2 along with the summary plots in Figures 75 through 81 should be referred to for a clearer picture of the results. In general, it was found that the 10 degree tilt angle nozzles started off fairly well at low rotation angles, and the pumping coefficients then fell off dramatically as the rotation angle was increased. The 15 degree tilt angle nozzles started out with good pumping coefficients at low rotation angles, reached a peak around the 15/20 combination, and then fell off for higher rotation angels. The 20 degree tilt angle nozzles started below the other two, got better, and then stayed the same as the rotatoin angle was increased.

The 22.5 degree tilt angle nozzles started out the lowest for this L/D ratio and got better with increasing rotation angles. Partial tests showed that primary flow coring took effect with these nozzles with poorer mixing once you passed a rotation angle of about 25 to 30 degrees depending on the tilt angle being tested.

One interesting point became clear by taking just the PCD data to establish a broader data base, the results clearly showed that not all angled nozzle combinations give better pumping performance than the straight nozzles, Several in the 10/30 and 10/40 ranges would be considerbaly worse in this application.

B. L/D = 1.5 (MEDIUM STACK) RESULTS

The L/D ratio of 1.5 mixing stack was installed, aligned,

and tested. The straight nozzles were then tested with a full data run to establish a base line for the medium stack data results. The results are given in the FT 46/23 series. The pumping coefficient fell to 0.51 while the MSD and VTD profiles were essentially the same as those for the longer stack.

Partial data runs were conducted for the remainder of the angles nozzle combinations. The results are provided in the various figures and tables, but again, the summaries in Table 1.2 and in Figures 75 through 81 present a clearer picture of the overall results. The 15/20 nozzles again provided the best pumping coefficient, and a full data run was then conducted. The results are given in the FT 53/30 series. The pumping coefficient was slightly better than 0.58, which compared favorably with the 0.59 pumping coefficient for the same nozzles on the longer L/D = 1.75 mixing stack. More importantly, the MSD profile improved considerably and there were no positive PMS* readings. The VTD profiles showed more peaks and troughs than with the longer stack, but overall, they were generally flatter, indicating better mixing. These findings were extremely important as they verified that the pumping coefficient could be kept close to those associated with straight nozzles and considerably longer mixing stacks, achieve better mixing, and the improved MSD profile clearly indicated that the ported mixing stack with shroud and diffusor end rings was also feasible. The 15/20 angled nozzle combina-

combination, based on data up to this point, clearly appeared to be the best combination irregardless of the mixing stack length and provided the best overall performance on the medium length mixing stack.

C. L/D = 1.25 (SHORT STACK) RESULTS

The L/D mixing stack was installed and aligned. The straight nozzles were again tested with a full data run to establish a baseline for the short mixing stack. The results are given in the FT 60/37 series. The pumping coefficient fell even further to 0.50 when compared to the two longer mixing stacks. The MSD profile was good, but it was poorer than those for the other two stacks. The VTD profiles had more pronounced peaks and troughs which were higher than those of any other stack and nozzle combination tested, thus indicating extremely poor mixing within the mixing stack.

Partial data runs were conducted on the remainder of the angled nozzle combinations. The results are provided in the various figures and tables, but again, the summaries in Table 1.3 and Figures 75 through 81 presents a clearer picture of the results. The 15/20 nozzles, the previously best performers on the other two stacks, fell below the pumping coefficients of the 15/10, 20/10, and 20/30 nozzles.

Full data runs were then conducted on the 15/20 and 20/20 nozzle combinations to determine the effects of increasing the L/D ratio while holding the 15/20 nozzle combination

constant and the effects of increasing the rotation angle while holding the tilt angle constant for the short stack.

The 15/20 nozzle combination on the full run dropped from 0.57 to 0.56 with better data accuracy. The results are given in the FT 67/44 series. The MSD profile, while always negative, was generally not as good as on the L/D = 1.5 mixing stack but better than on the long stack. The VTD profiles were better than the straight nozzles, but not quite as good as either of the longer mixing stacks.

The 20/20 nozzle combination had a pumping coefficient of 0.58 which was better than the 15/20 nozzles. The results of this run are given in the FT 71/48 series. The biggest difference between these two combinations was in the MSD profiles. The 20/20 nozzle combination had two positive PMS* readings near the mixing stack exit as well as a poorer overall profile. There was some misalignment on the VTD profiles but in general, the horizontal profile was better than with the 15/20 nozzles while the diagonal profile was considerably worse with indications of some wall effects. Overall, the VTD profiles were about equal for mixing properties.

The 20/30 nozzles should have been slightly poorer performers than the 20/20 nozzles, and a full data run was not conducted. The next step would have been to conduct full data runs on the 15/10 nozzle combination; however, time expired for data acquisition and was needed to analyze data and write this report. This testing of the 15/10 nozzle combination would make an excellent starting point for the next research effort.

D. BACK PRESSURES

A review of the back pressure data from the various data tables showed that the better performing angled primary flow nozzles increased the back pressures on the average of 0.04 inches of water when compared to the straight nozzles on the same mixing stack. For example, the 15/20 nozzles on the L/D = 1.5 mixing stack increased the back pressure only 0.02 inches of water for the test uptake Mach number of 0.062. Increasing the nozzle tilt angle about 20 degrees and the nozzle rotation angle above 25 degrees tended to raise the back pressures slightly, usually on the order of several tenths of inches of water. A firm correlation between the effects of increasing just one or both of the angles could not be obtained. For example, the 22.5/20 nozzles on the L/D = 1.25 mixing stack showed 0.15 inches of water less back pressure than the 22.5/10 nozzles; however, they both were at least 0.35 inches of water greater than the straight nozzles.

The 15/20 nozzles with the L/D = 1.5 mixing stack showed a back pressure of 6.30 inches of water for a test Mach number of 0.064. The straight nozzles used with the longer L/D = 2.5 mixing stack were shown by Lemke and Staehli to have a back pressure of 5.8 inches of water, therefore the angled nozzles when used in the shorter mixing stacks do exhibit a slight increase in back pressure on the order of one-half inch of water.

VIII. CONCLUSIONS

This research investigated the feasibility of reducing the length of the mixing stacks in gas turbine gas eductor systems by the use of angled primary flow nozzles. The conclusions resulting from this investigation are as follows:

1. The best combination of angled primary flow nozzles and mixing stacks tested appears to be the angled nozzles with an area ratio of 2.5, a tilt angle of 15 degrees, and a rotation of 20 degrees used in a mixing stack with an L/D ratio of 1.5 and an S/D ratio of 0.5. This combination provides a pumping coefficient of 0.58, which is equal to that reported by Lemke and Staehli for straight nozzles with the same area ratio used in a mixing stack with an L/D ratio of 2.5 and S/D ratio of 0.5. The best combination of angled nozzles and mixing stack, when further compared to this longer mixing stack, showed comparable mixing stack pressure distributions, a slight increase in back pressure of 0.50 inches of water, and improved mixing.
2. The family of 15 degree tilt angled primary flow nozzles provides the best overall eductor performance when evaluated by all parameters on the mixing stacks investigated. Not all angled nozzles tested gave

improved performance over straight primary flow nozzles for the same AR, L/D, and S/D ratios. Some of the angled primary flow nozzles which do give good pumping capacity provide poor mixing and/or mixing stack pressure distributions. The best combination of angled primary flow nozzles and mixing stack previously listed shows strong potential for further application of the shrouded, ported, and diffusor ring equipped mixing stack concept.

3. The S/D ratio of 0.5 appears to be the preferred overall location of the mixing stack from the primary flow nozzles. The angled nozzles appear to behave in this respect much like straight nozzles, and follow the general behavior obtained by Moss for varying the stand-off ratios.

4. Back pressure increases associated with the angled primary flow nozzles are insignificant when compared with straight nozzles used with the same L/D ratio mixing stacks, provided that the nozzle tilt angle is kept below approximately 20 degrees and the nozzle rotation is kept below approximately 25 degrees.

IX. RECOMMENDATIONS FOR FURTHER STUDY

Based upon a review of this investigation and its findings, it is recommended that further study be conducted in the following areas:

1. Full data runs be conducted for the 15/10 nozzle combinations on the L/D = 1.25 and L/D = 1.5 mixing stacks to establish a more complete data base for the 15 degree tilt angle nozzles.
2. More verification of S/D ratio effects at 10/20 and 15/20 nozzle combinations on the above L/D ratio mixing stacks.
3. Investigate the application of angled primary flow nozzles on ported, shrouded, and diffusor ring equipped short mixing stacks to further enhance short mixing stack performance.
4. Investigate alternate nozzle cross sections, such as the flutted nozzle, to further enhance the mixing process in short mixing stacks. This research could also later be applied to the ported, shrouded, and diffusor ring equipped short stacks.
5. Hot flow verification of cold flow findings should conducted once the above recommendations have established the better performing geometries and configurations for short mixing stack and gas eductor enhancement in gas turbine applications.

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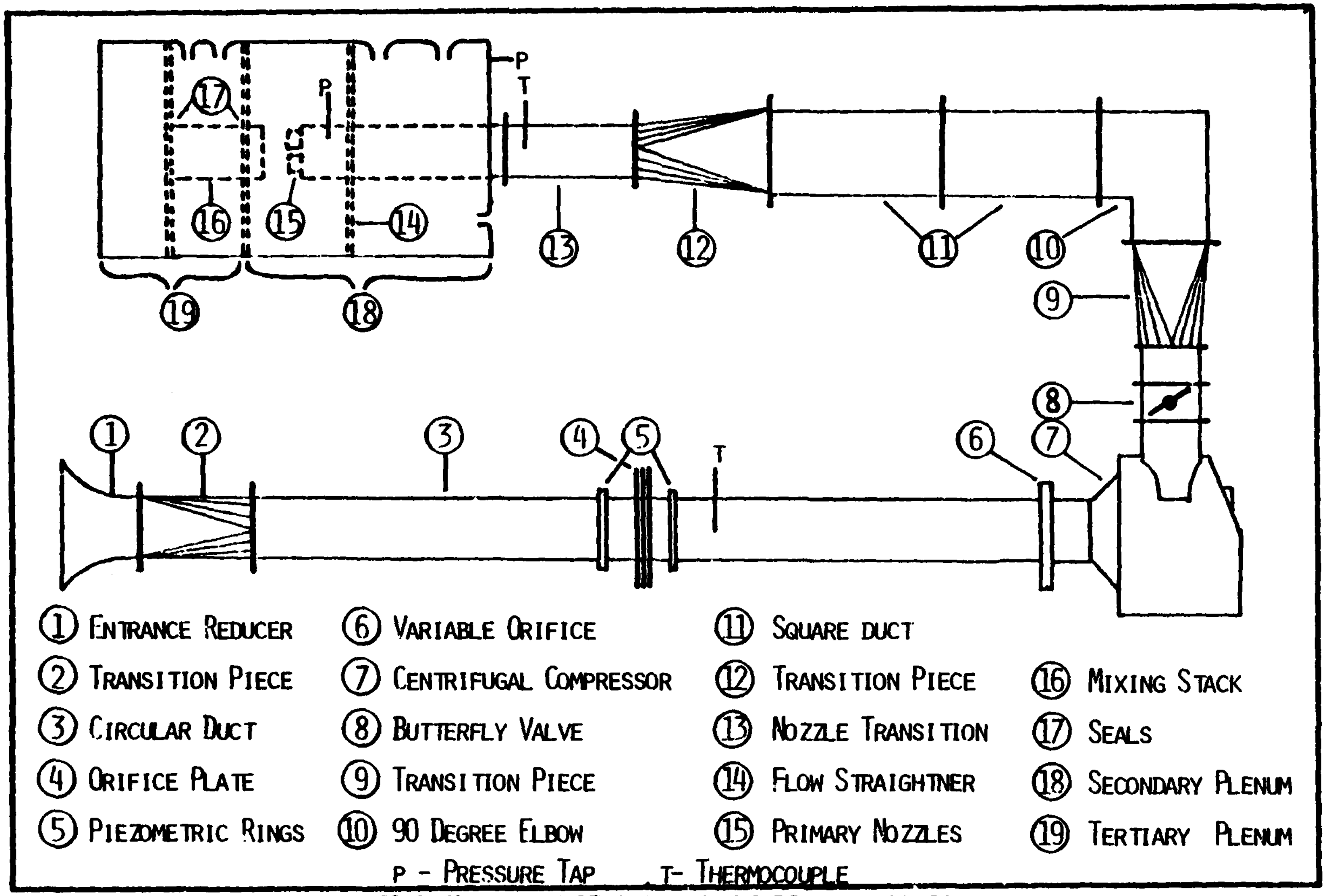
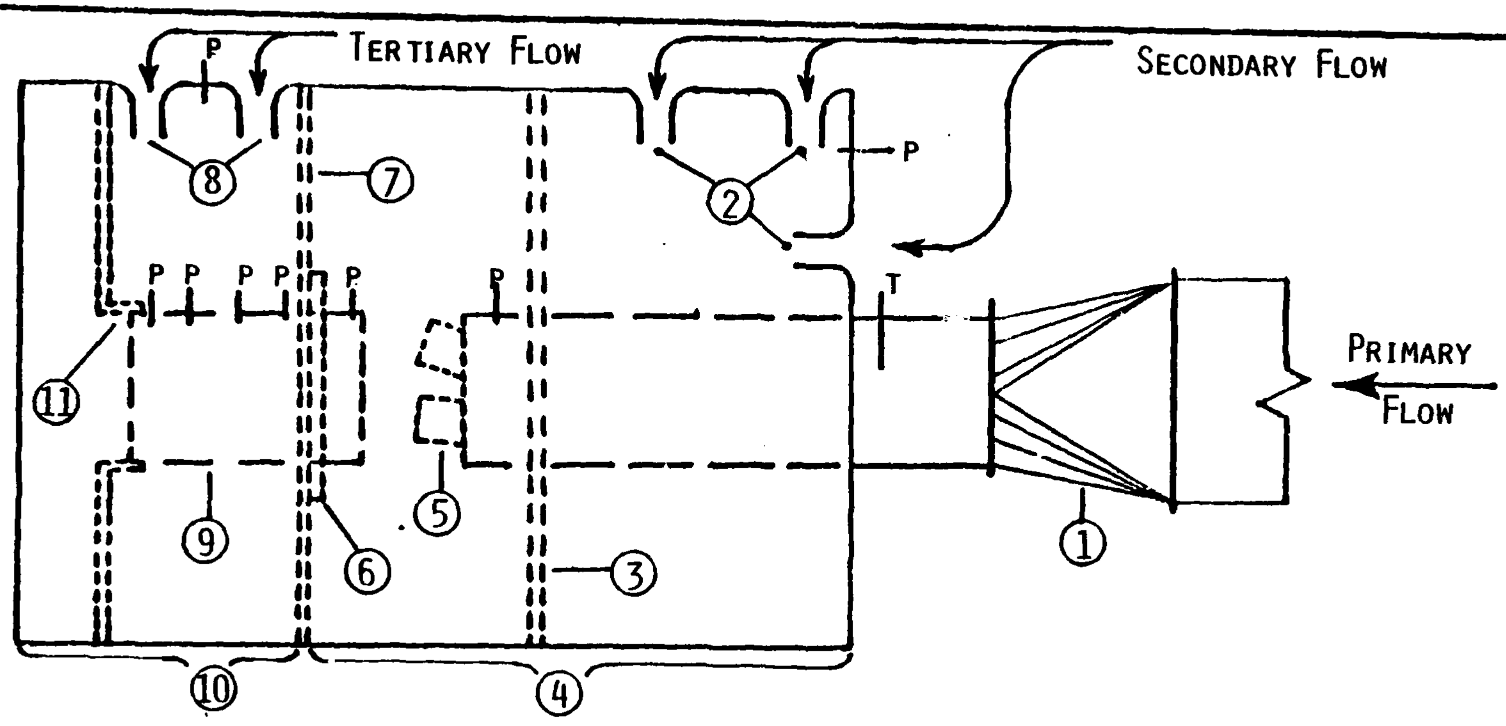


FIGURE 1 - EDUCTOR MODEL TESTING FACILITY



1 TRANSITION
2 ASME LONG RADIUS NOZZLES
3 FLOW STRAIGHTNER
4 SECONDARY AIR PLENUM
5 ANGLED PRIMARY NOZZLES
6 AIR SEAL
7 INTER-PLENUM SEAL
8 ASME LONG RADIUS NOZZLES
9 MIXING STACK
10 TERTIARY PLENUM
11 AIR SEAL
P PRESSURE TAP
T THERMOCOUPLE

FIGURE 2 - GAS EDUCTOR MODEL TEST FACILITY WITH SECONDARY AND TERTIARY PLENUMS

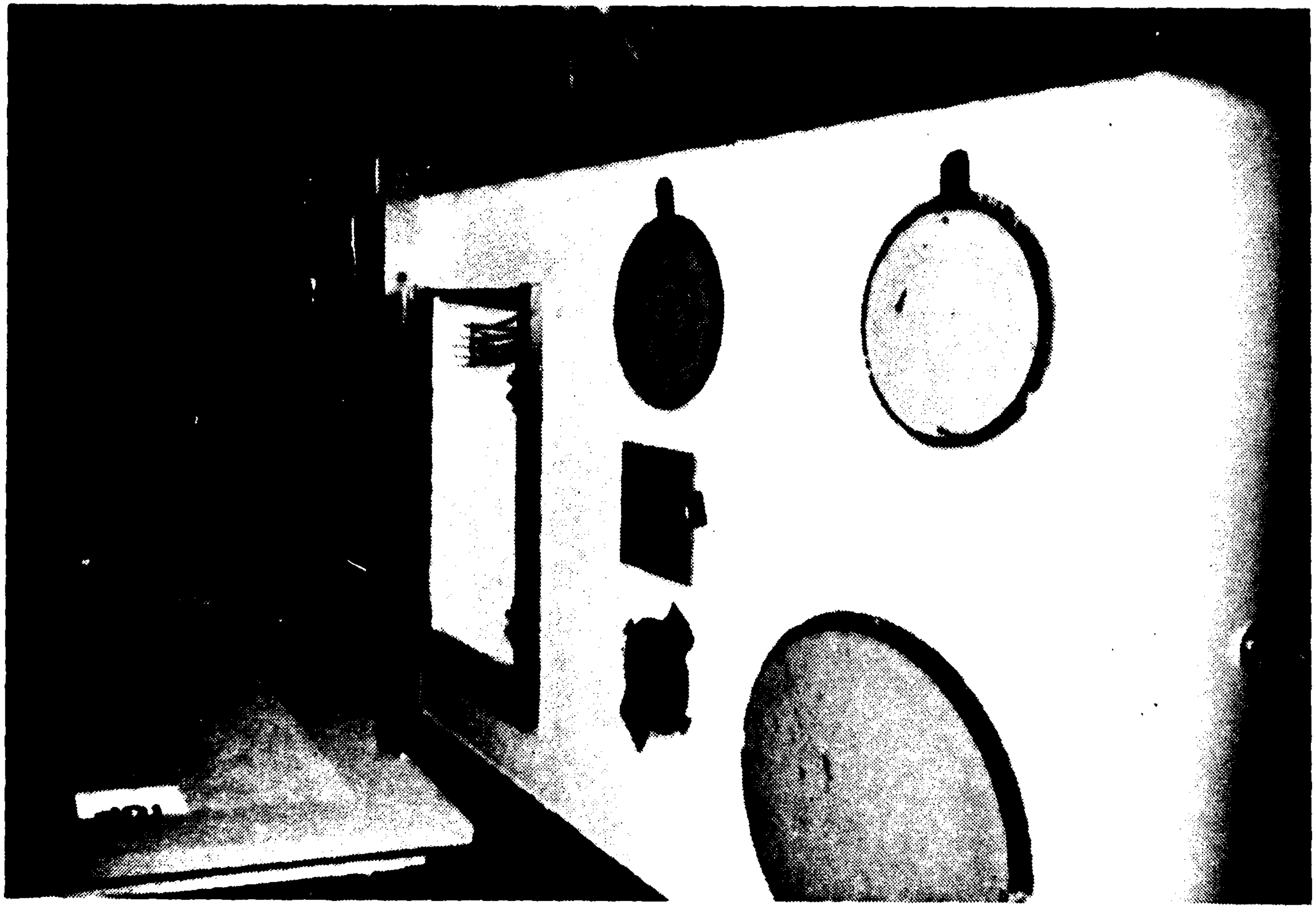


FIGURE 3 - EXTERIOR OF SECONDARY PLENUM WITH PLENUM DOOR OFF AND ASME FLOW NOZZLES CLOSED

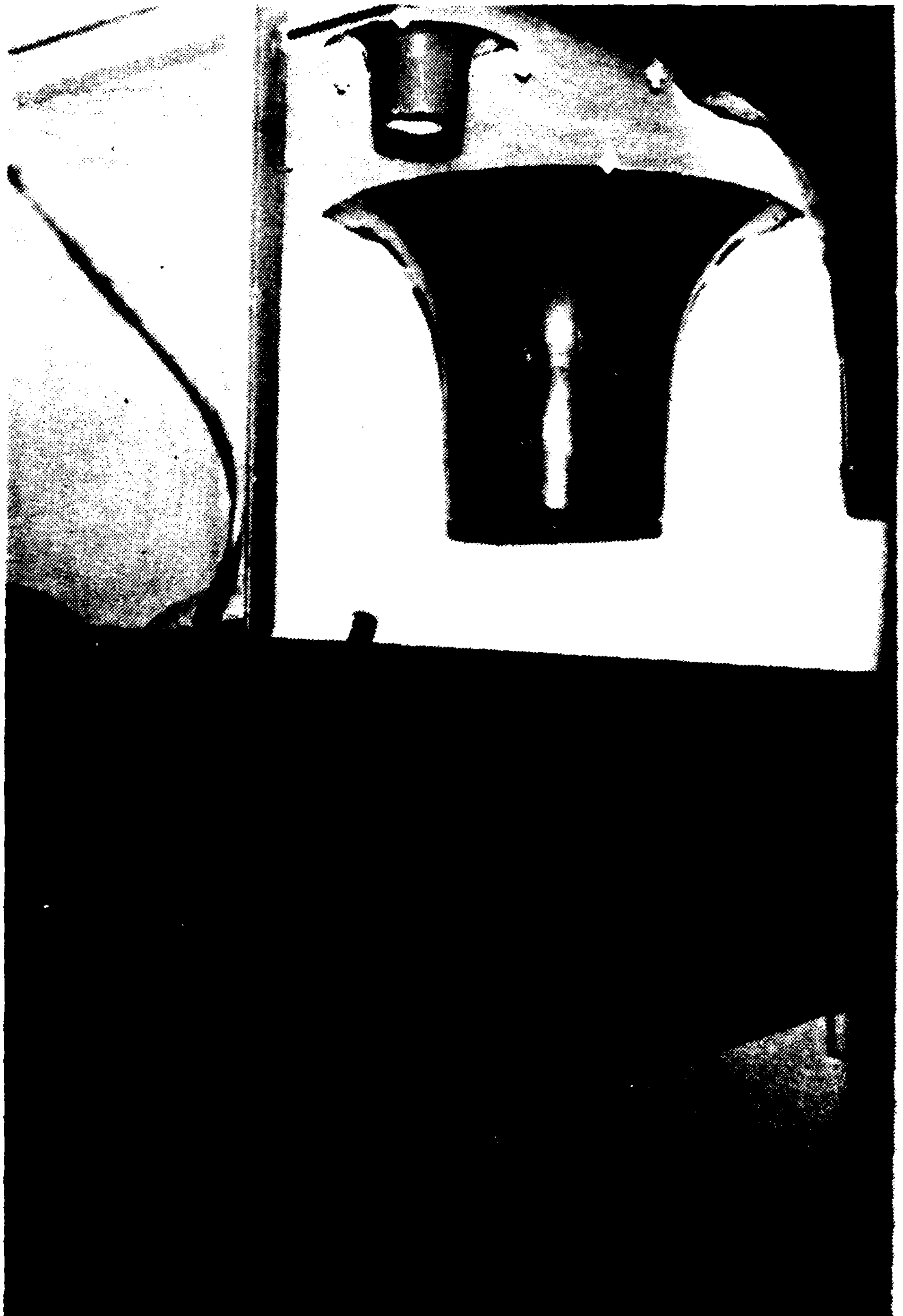


FIGURE 4 - INTERIOR OF SECONDARY PLENUM WITH ONE OF TWO FLOW STRAIGHTNERS REMOVED TO ALLOW VIEWING OF ASME FLOW NOZZLES AND NOZZLE TRANSITION DUCT

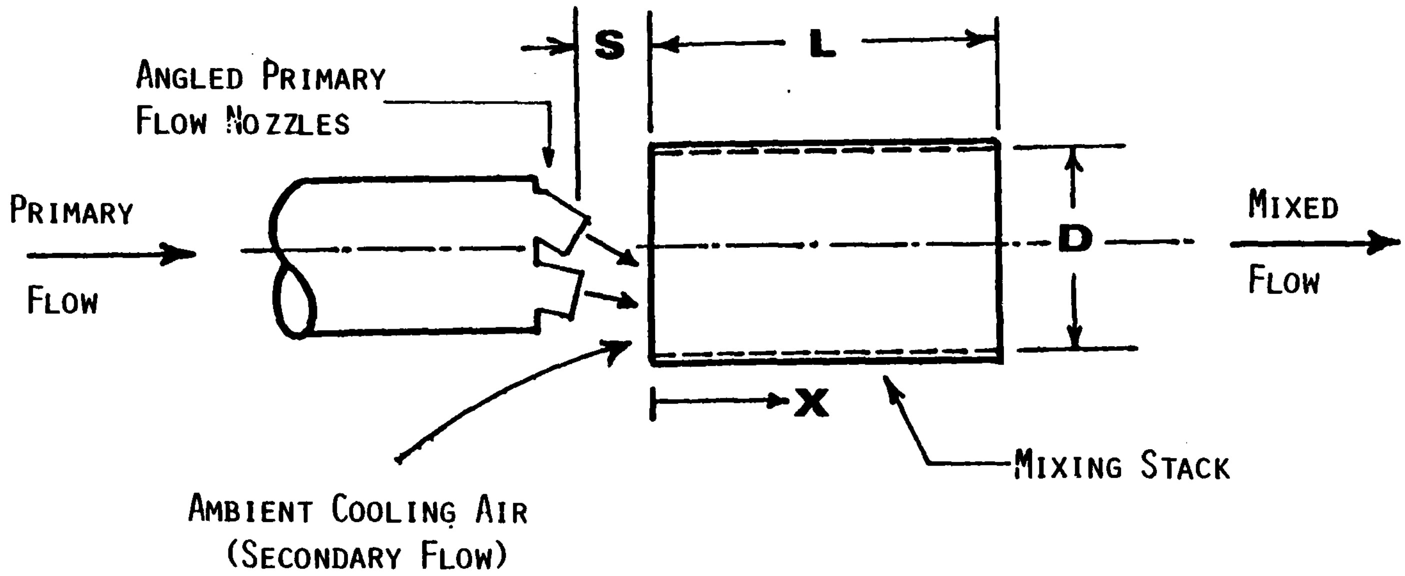
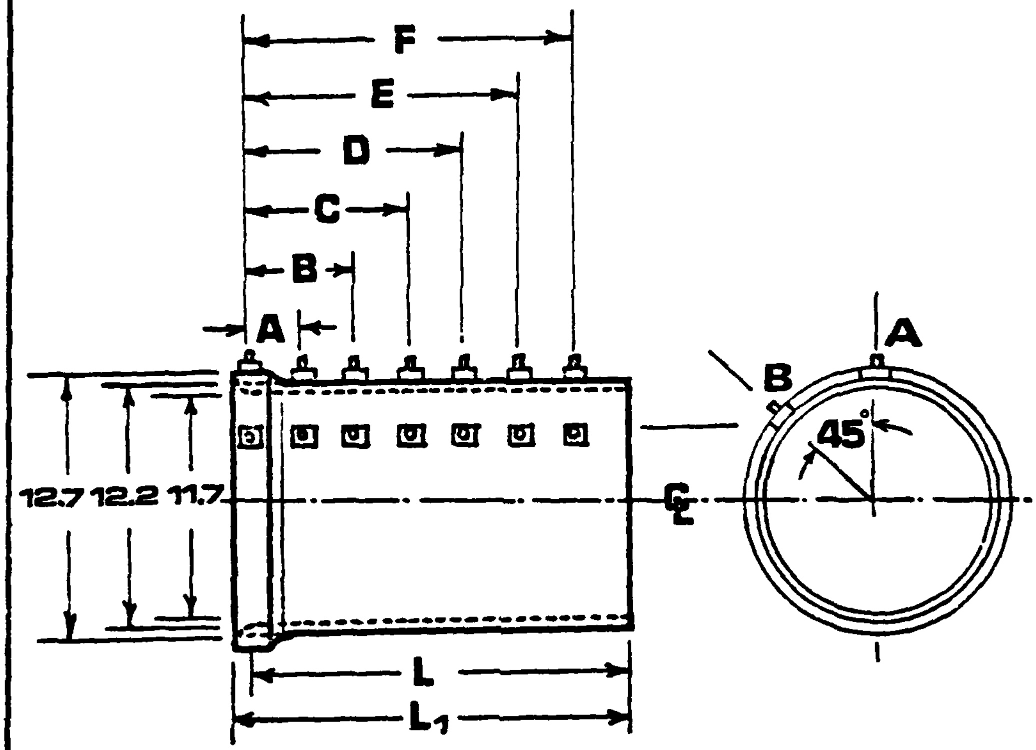


FIGURE 5 - SCHEMATIC OF STRAIGHT MIXING STACK GAS EDUCTOR WITH ANGLED NOZZLES



L/D=1.75	L/D=1.50	L/D=1.25
L = 20.48"	L = 17.55"	L = 14.63"
L_1 = 20.98"	L_1 = 18.05"	L_1 = 15.13"
A = 2.93"	A = 2.93"	A = 2.93"
B = 5.85"	B = 5.85"	B = 5.85"
C = 8.78"	C = 8.78"	C = 8.78"
D = 11.70"	D = 11.70"	D = 11.70"
E = 14.63"	E = 14.63"	E = 14.13"
F = 17.55"		

FIGURE 6 - DIMENSIONS FOR SHORT MIXING STACKS INVESTIGATED

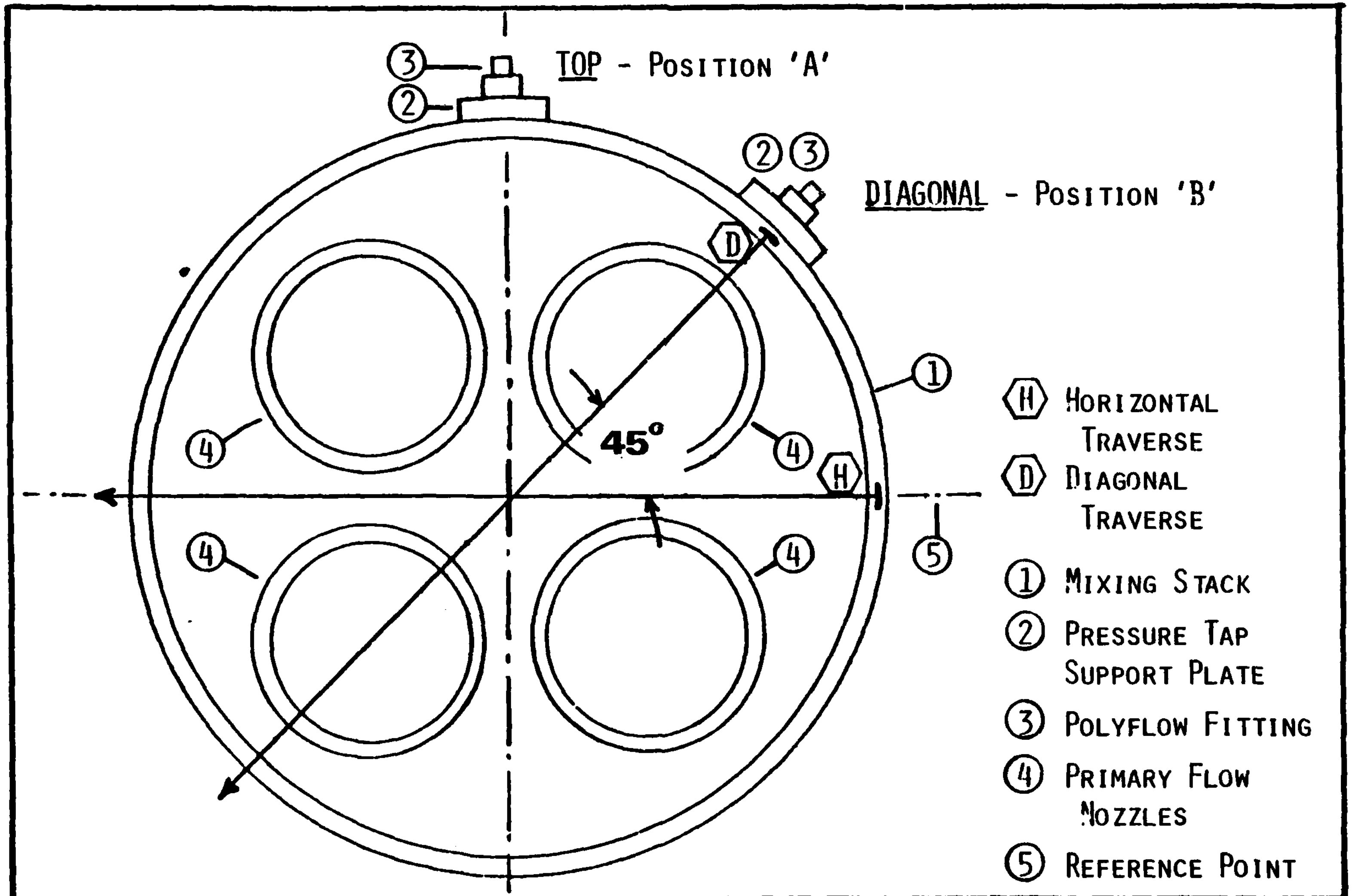


FIGURE 7 - MIXING STACK EXIT WITH VELOCITY PROFILE DIRECTIONS AND PRESSURE TAP LOCATIONS

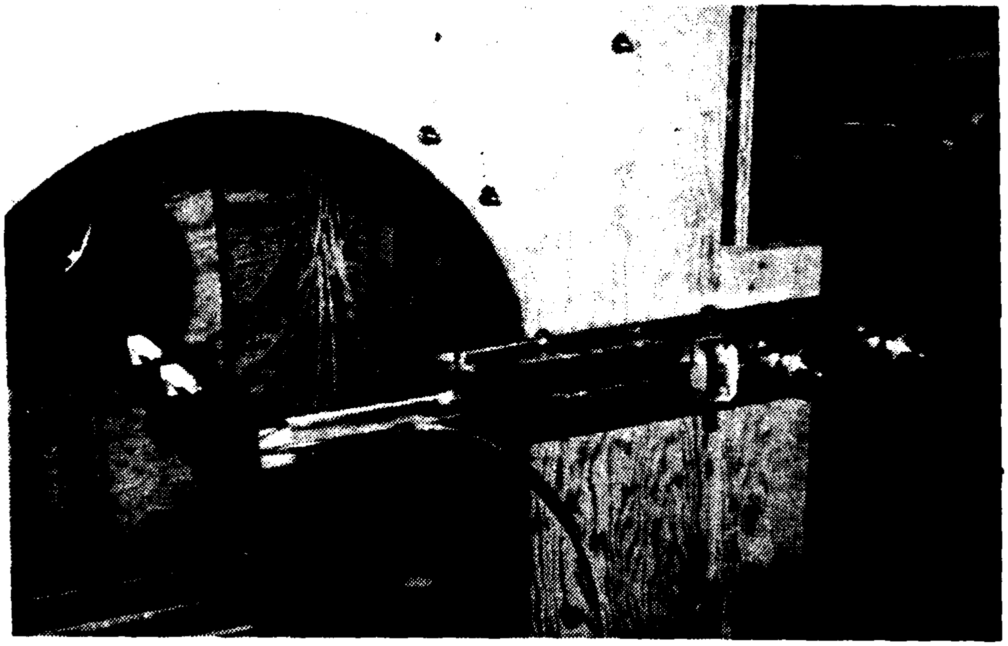


FIGURE 8 - VELOCITY TRAVERSE BAR AND MIXING STACK

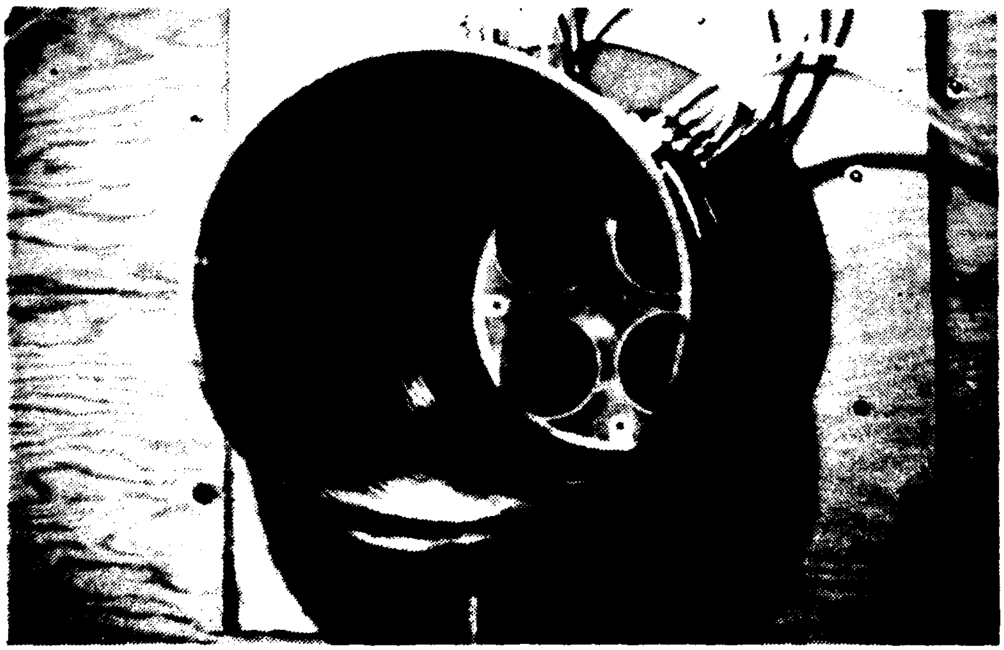
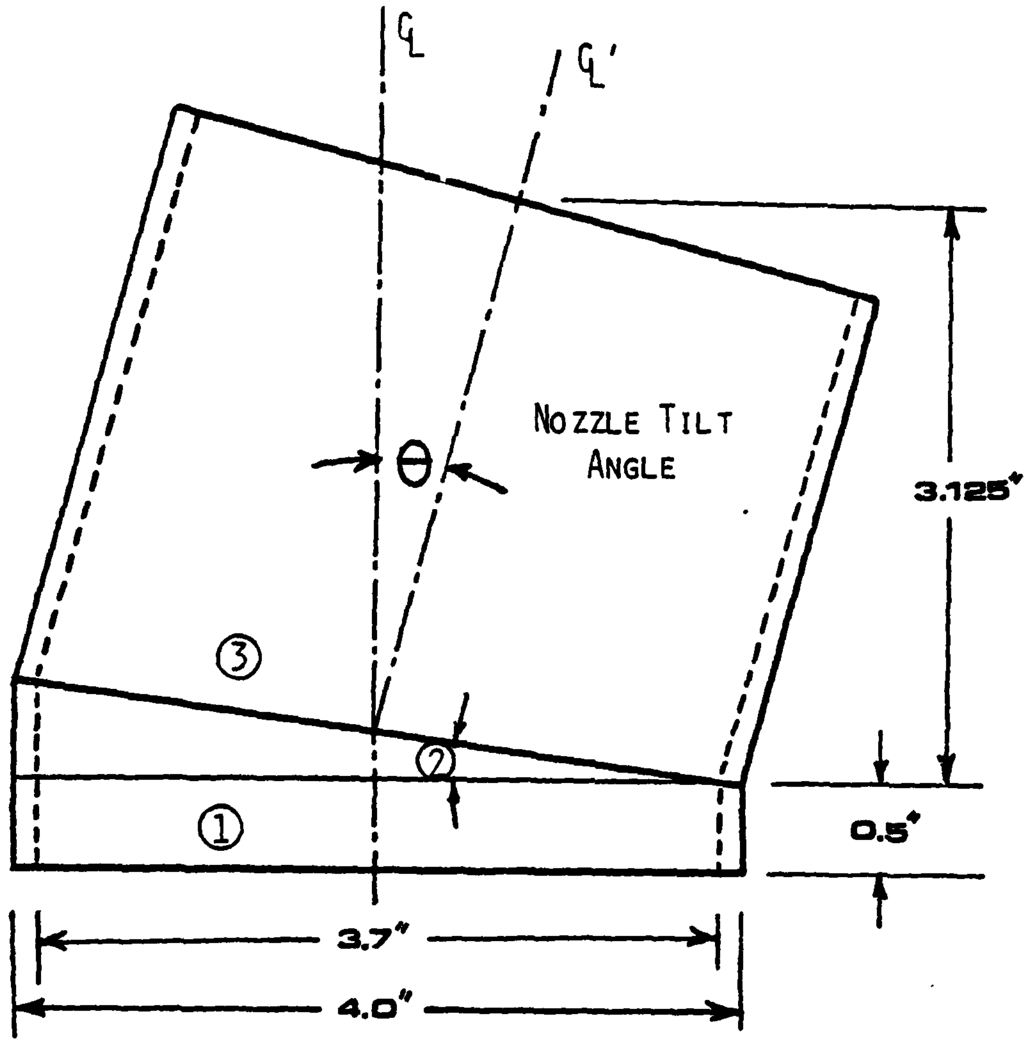


FIGURE 9 - MIXING STACK WITH PRESSURE TAPS AND AIR SEAL



① 0.5 INCH MACHINED SURFACE TO FIT THE NOZZLE BASE PLATE RECESSES

② MITER ANGLE - ONE-HALF OF THE TILT ANGLE

③ CUT AND JUNCTURE LINE

NOTE: FOUR SETS OF ANGLED NOZZLES WERE CONSTRUCTED WITH TILT ANGLES OF 10, 15, 20, AND 22.5 DEGREES.

FIGURE 10 - DIMENSIONS OF ANGLED NOZZLES AND NOZZLE TILT ANGLE

FIGURE 11 - ANGLED PRIMARY FLOW NOZZLE

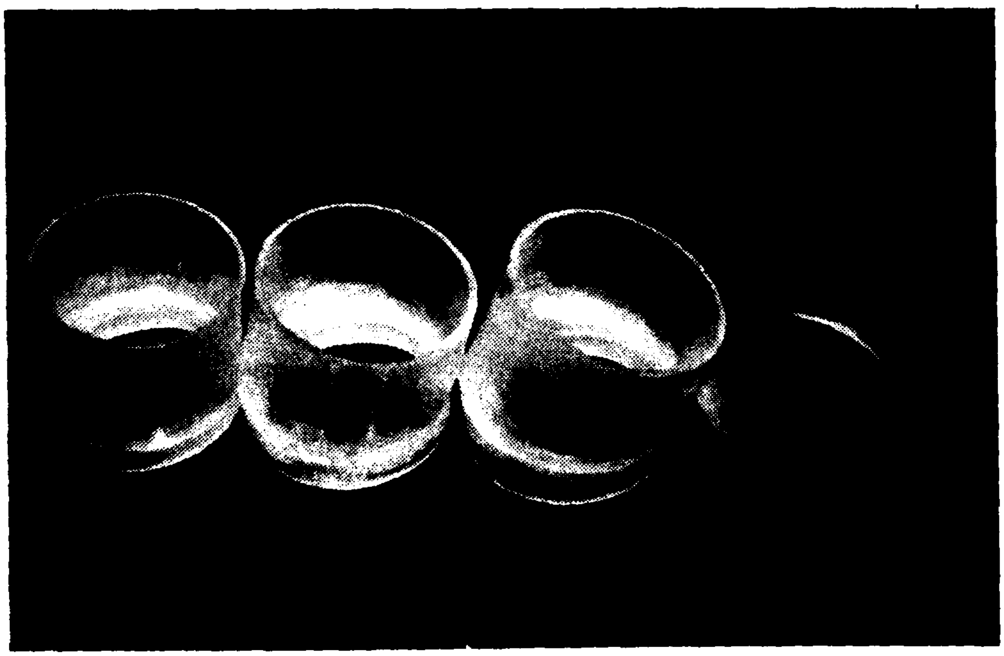
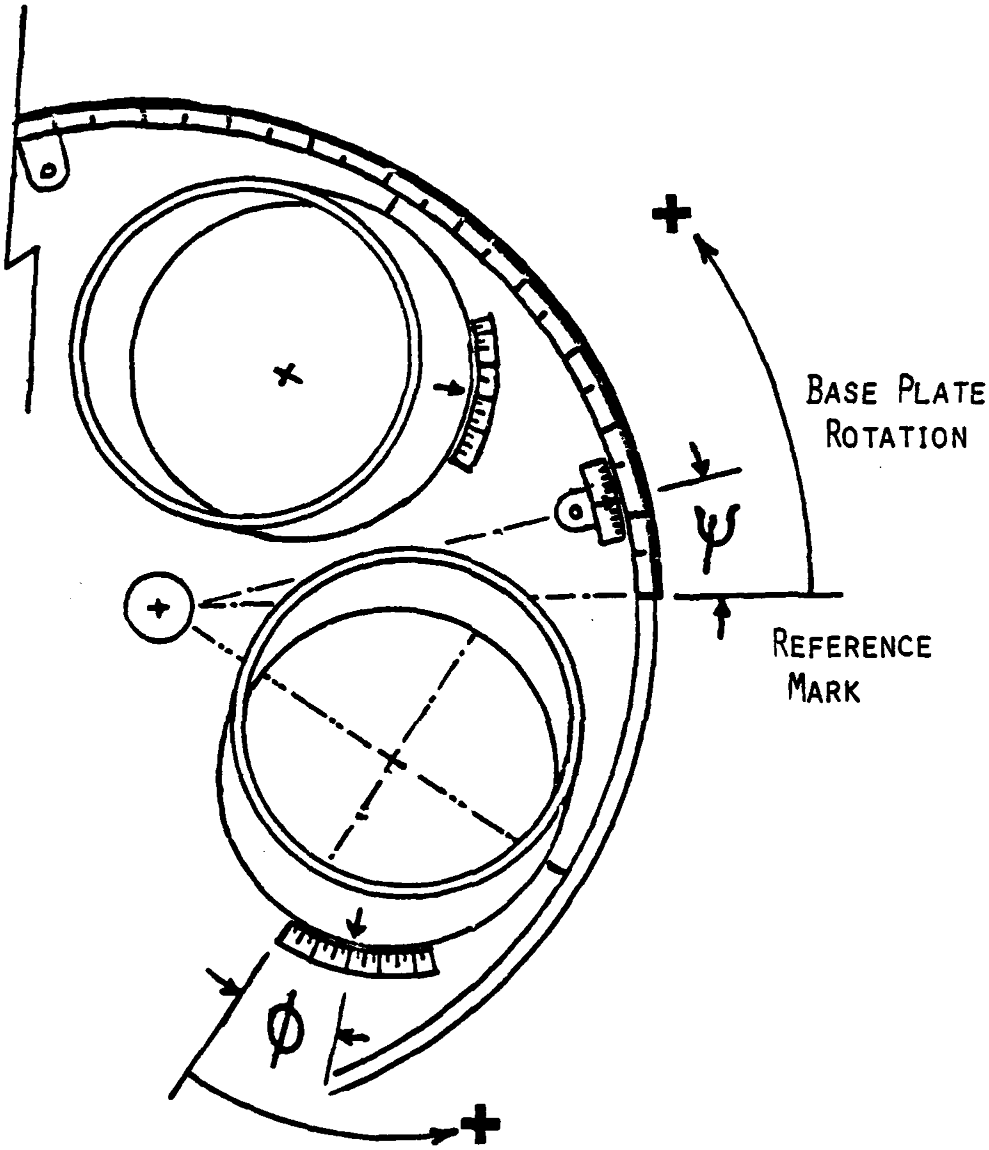


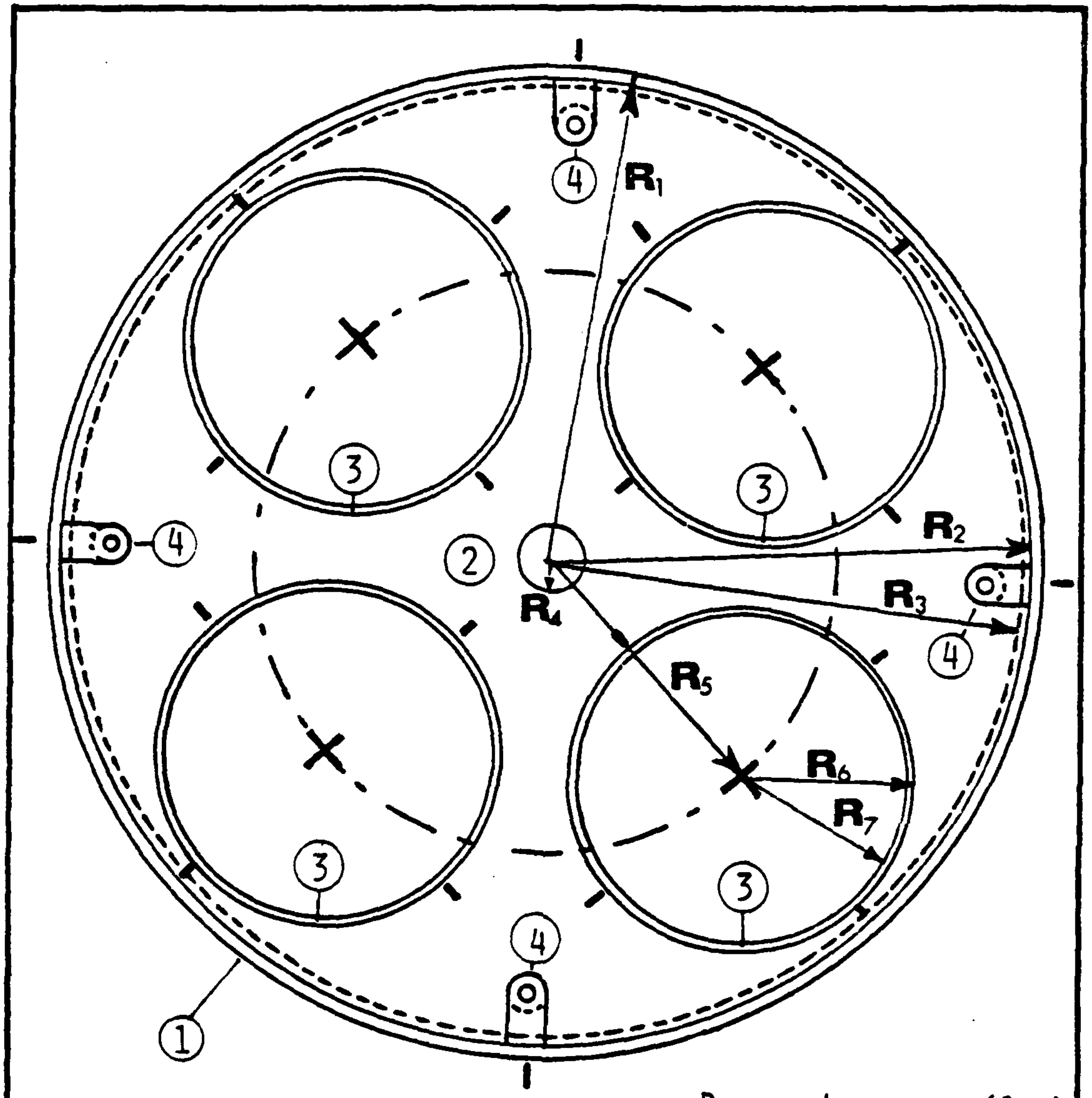
FIGURE 12 - ANGLED NOZZLES WITH TILT ANGLES 10 TO 22.5 DEGREES



ANGLED NOZZLE ROTATION

NOTE: THIS ILLUSTRATION SHOWS A SET OF 15 DEGREE TILT ANGLE NOZZLES WITH 20 DEGREES OF ROTATION WITH A BASE PLATE ROTATION OF 13 DEGREES.

FIGURE 13 - BASE PLATE ROTATION ANGLE AND NOZZLE ROTATION ANGLE



RADIUS LISTINGS (IN.)

R_1	= 5.750
R_2	= 5.600
R_3	= 5.400
R_4	= 0.375
R_5	= 3.200
R_6	= 2.000
R_7	= 1.850

1. FIXED OUTER RING
2. ROTATIONG BASE PLANT
3. RECESSES FOR ANGLED NOZZLES
4. LOCKING CAMS

FIGURE 14 - DIMENSIONS FOR THE ROTATABLE NOZZLE BASE PLATE

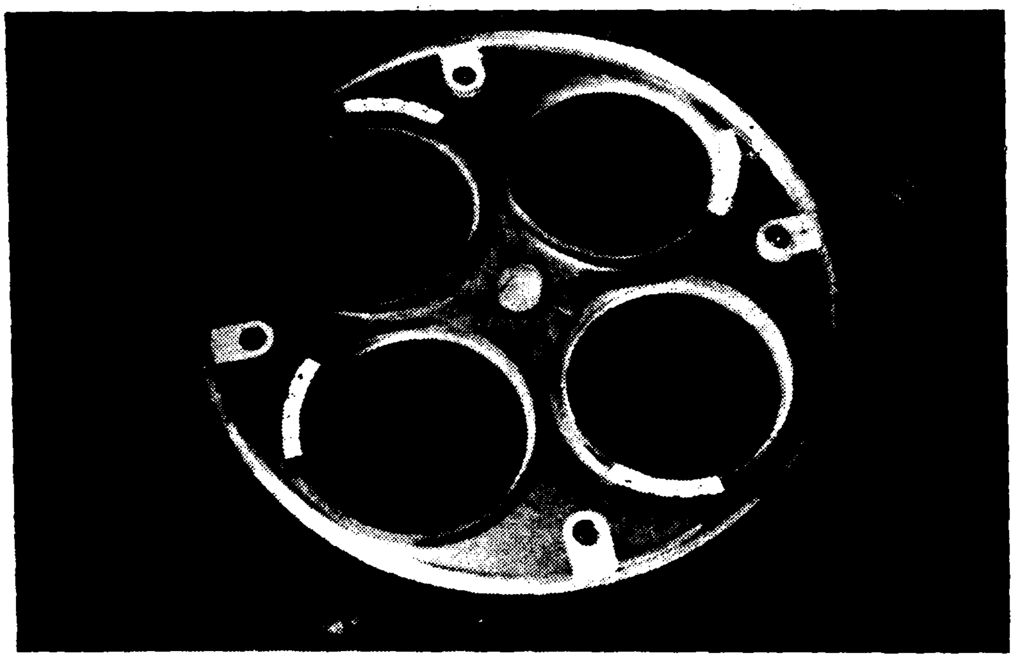


FIGURE 15 - ROTATABLE BASE PLATE FOR ANGLED NOZZLES

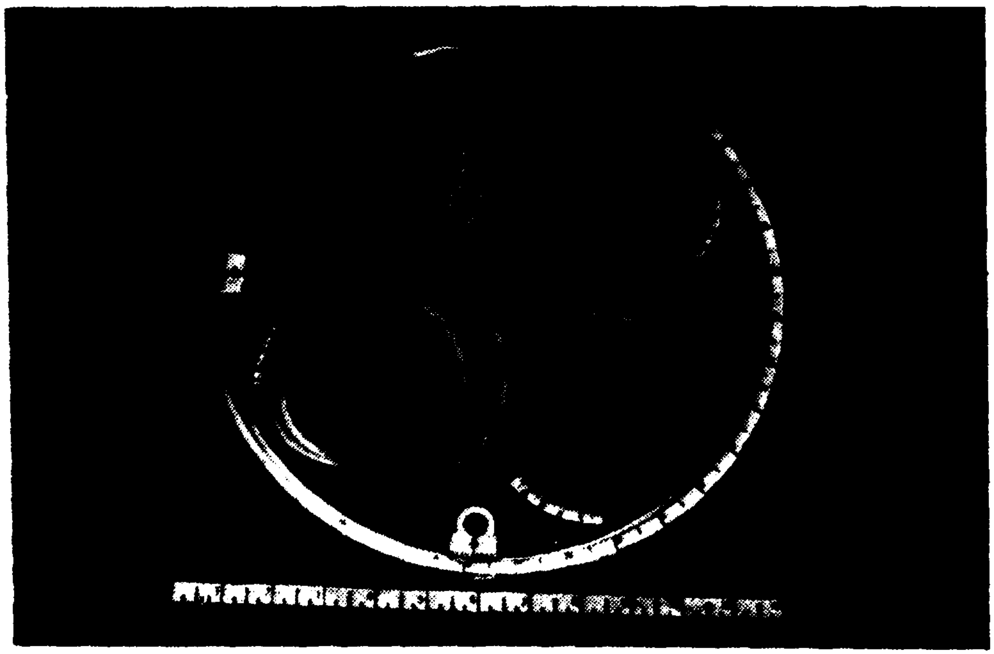


FIGURE 16 - BASE PLATE WITH A 20/20 NOZZLE COMBINATION

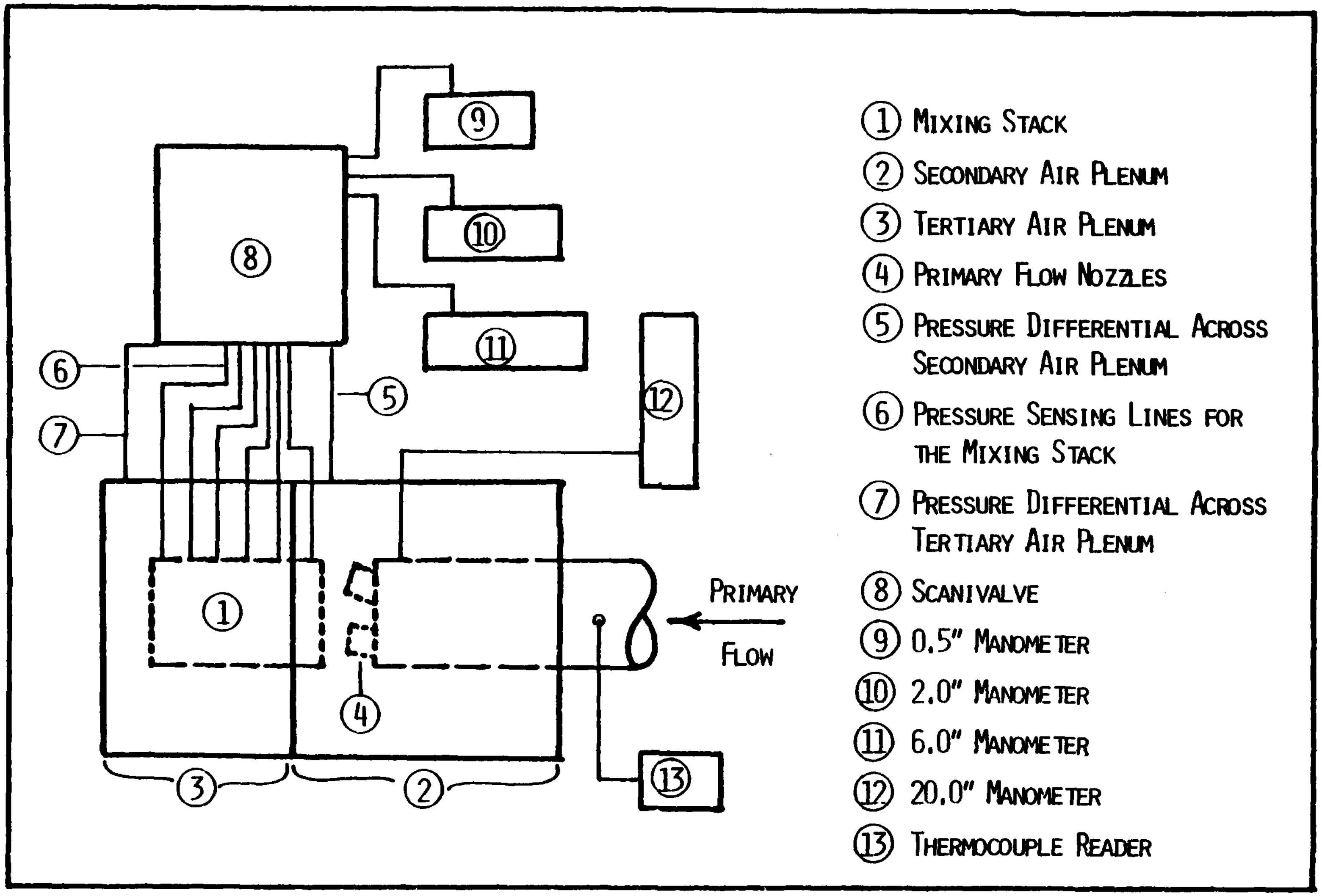


FIGURE 17 - SCHEMATIC OF INSTRUMENTATION

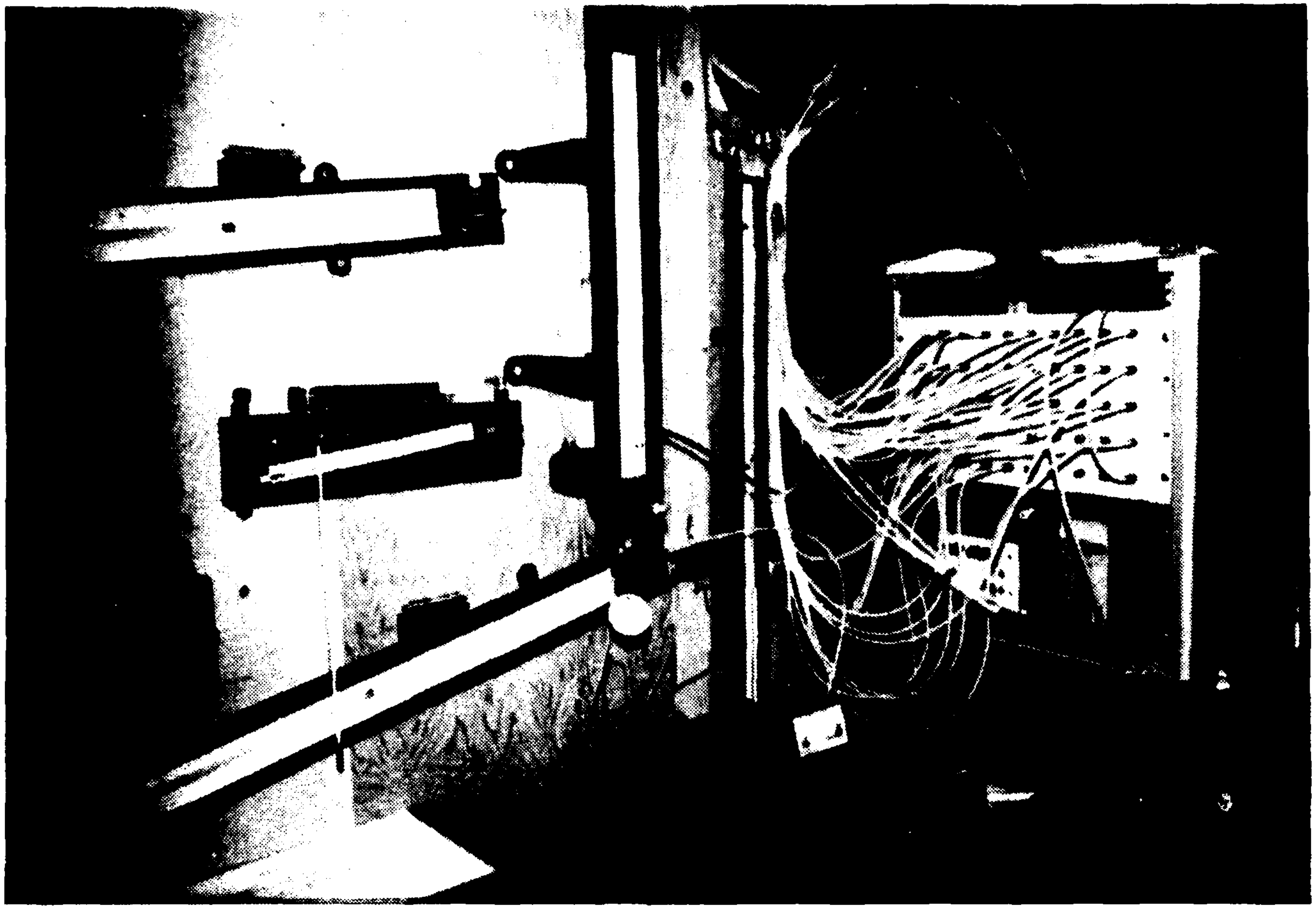


FIGURE 18 - INSTRUMENTATION

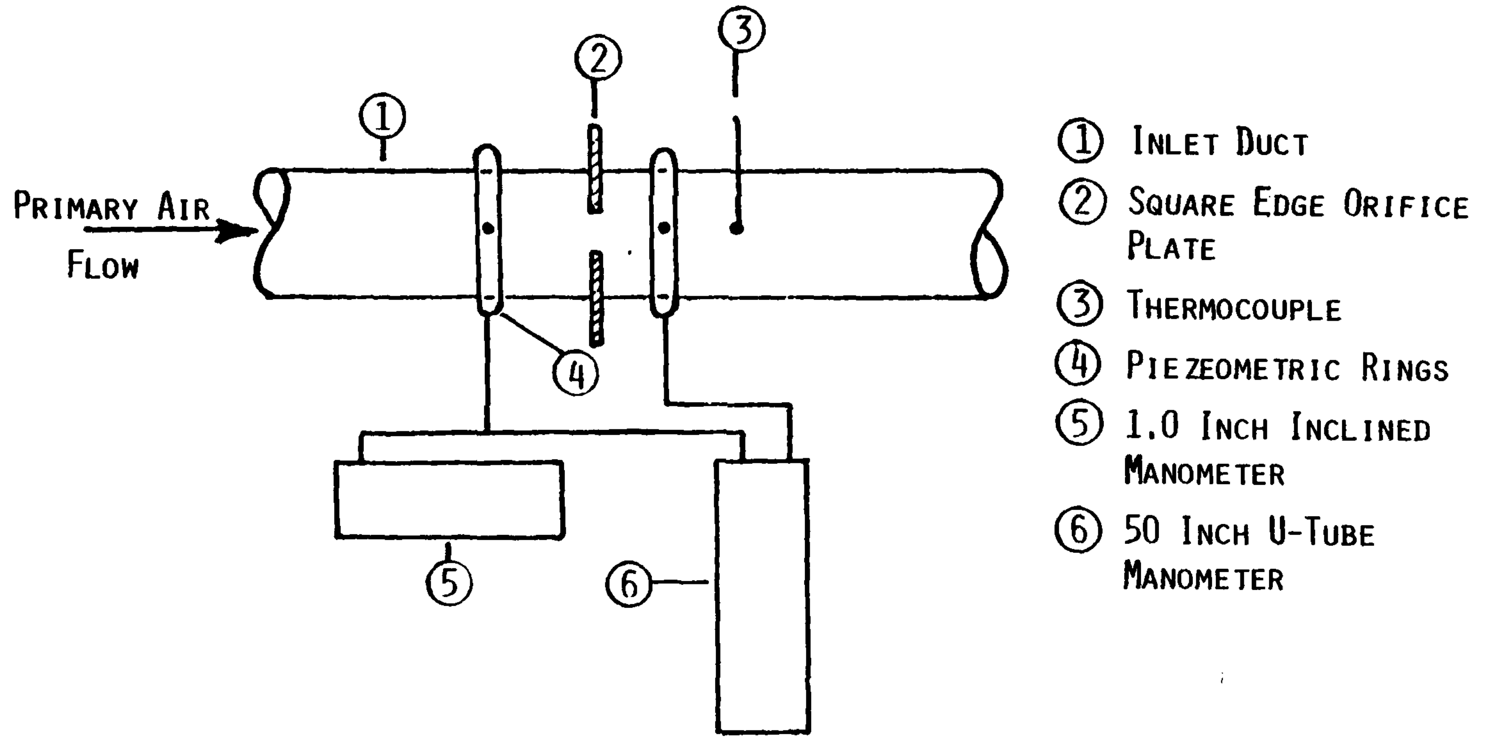


FIGURE 19 - SCHEMATIC OF INSTRUMENTATION FOR PRIMARY AIR FLOW MEASUREMENT

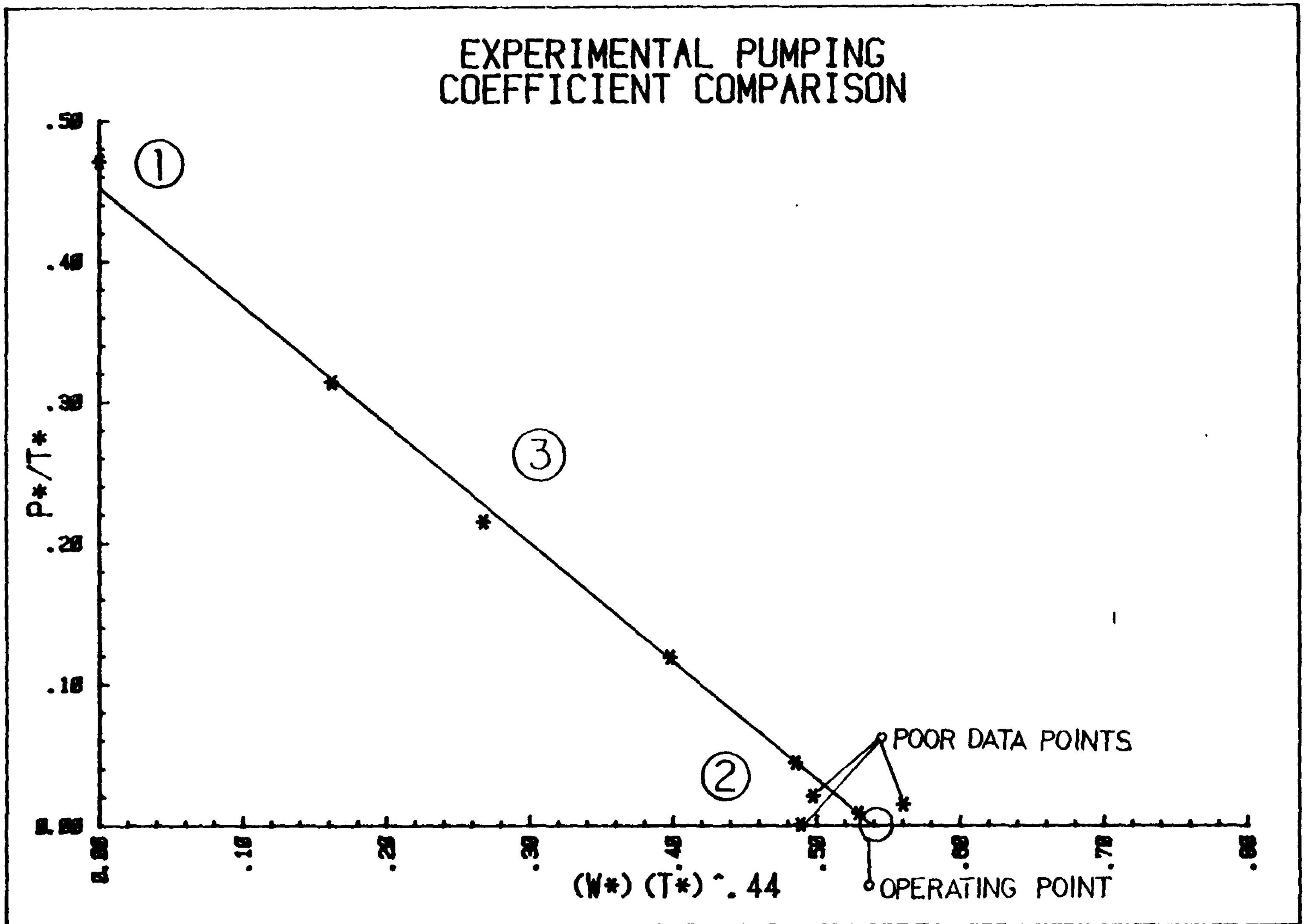


FIGURE 20 - SAMPLE PUMPING COEFFICIENT PLOT

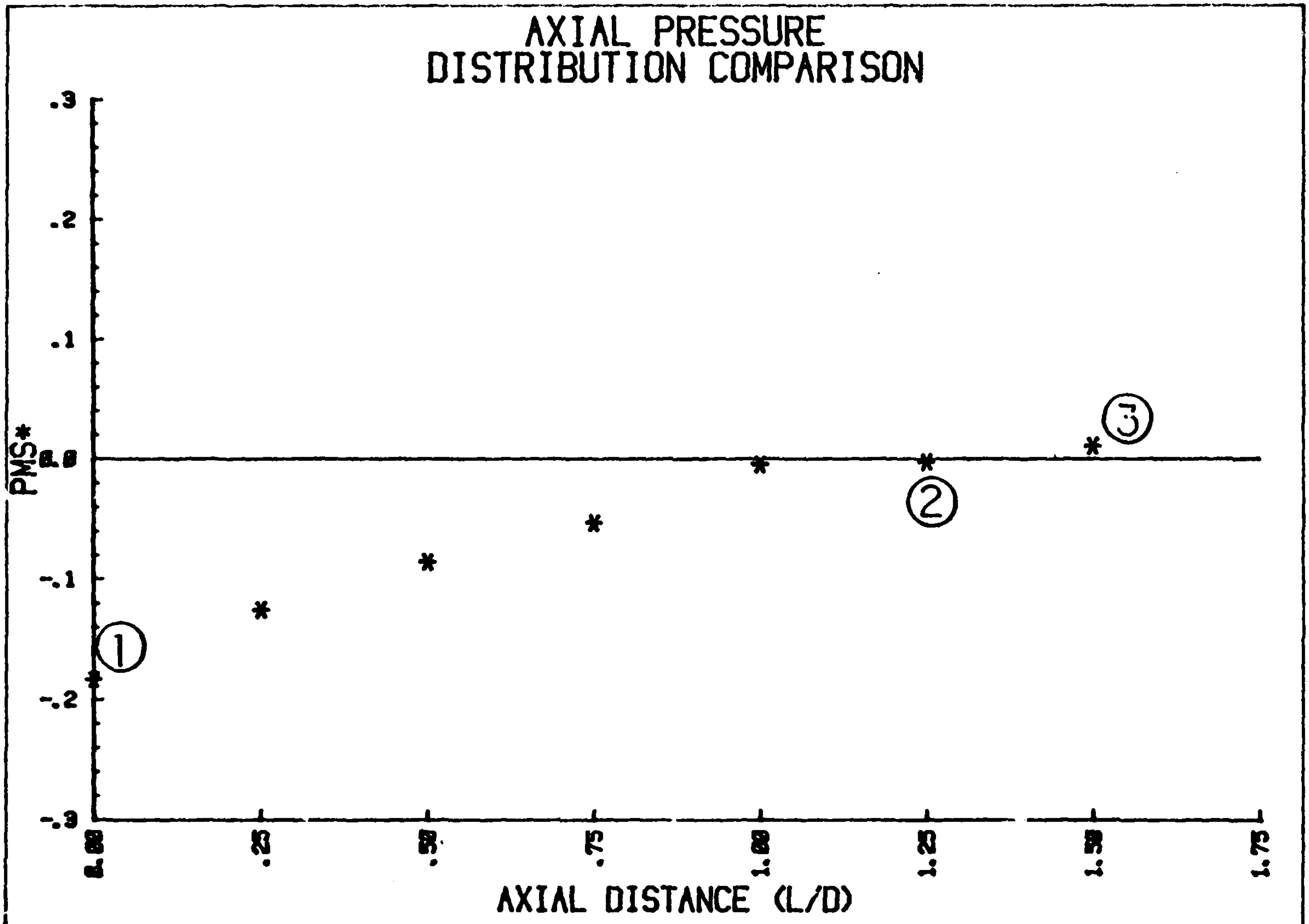


FIGURE 21 - SAMPLE MIXING STACK PRESSURE DISTRIBUTION PLOT

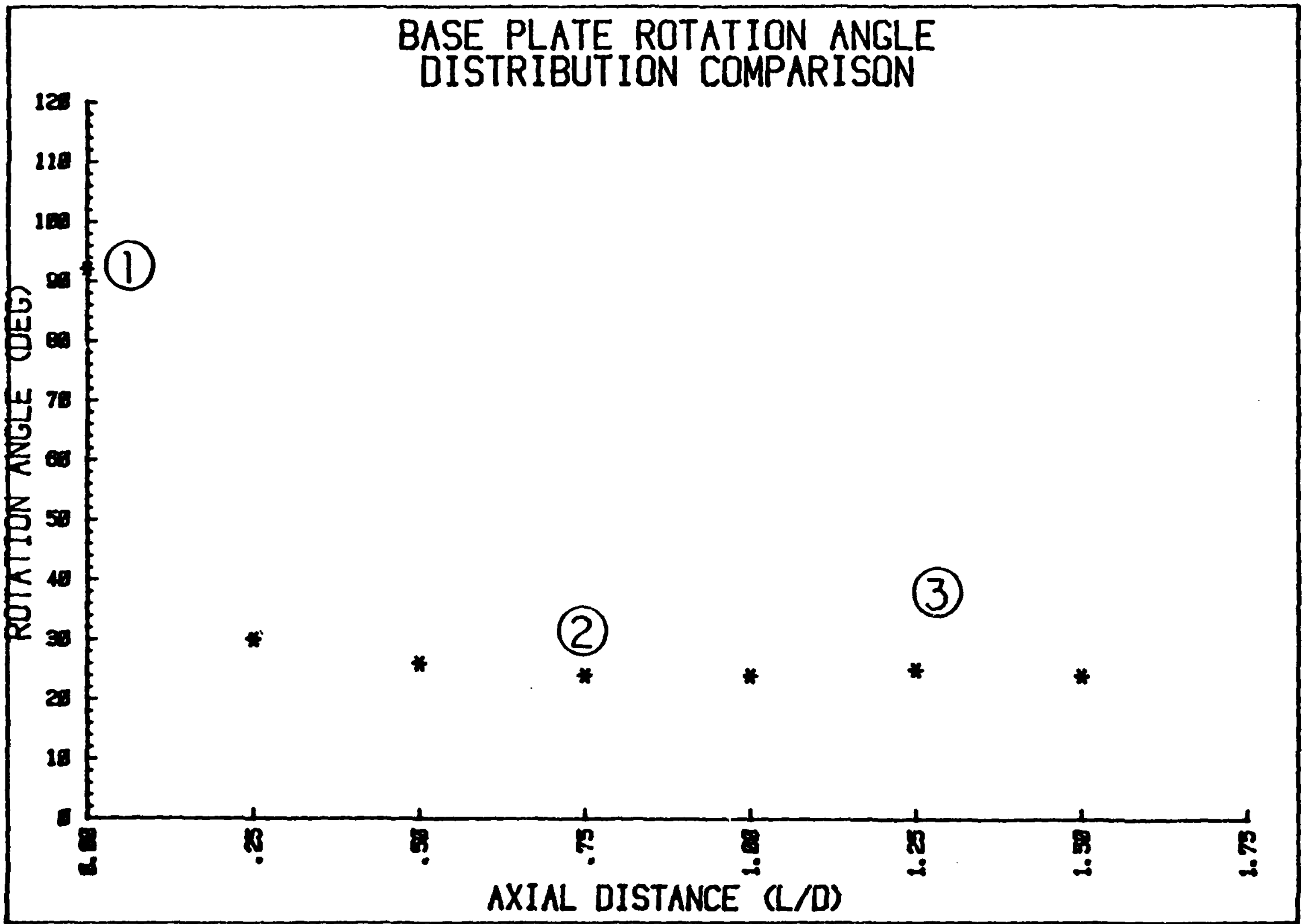


FIGURE 22 - SAMPLE BASE PLATE ROTATION ANGLE DISTRIBUTION PLOT

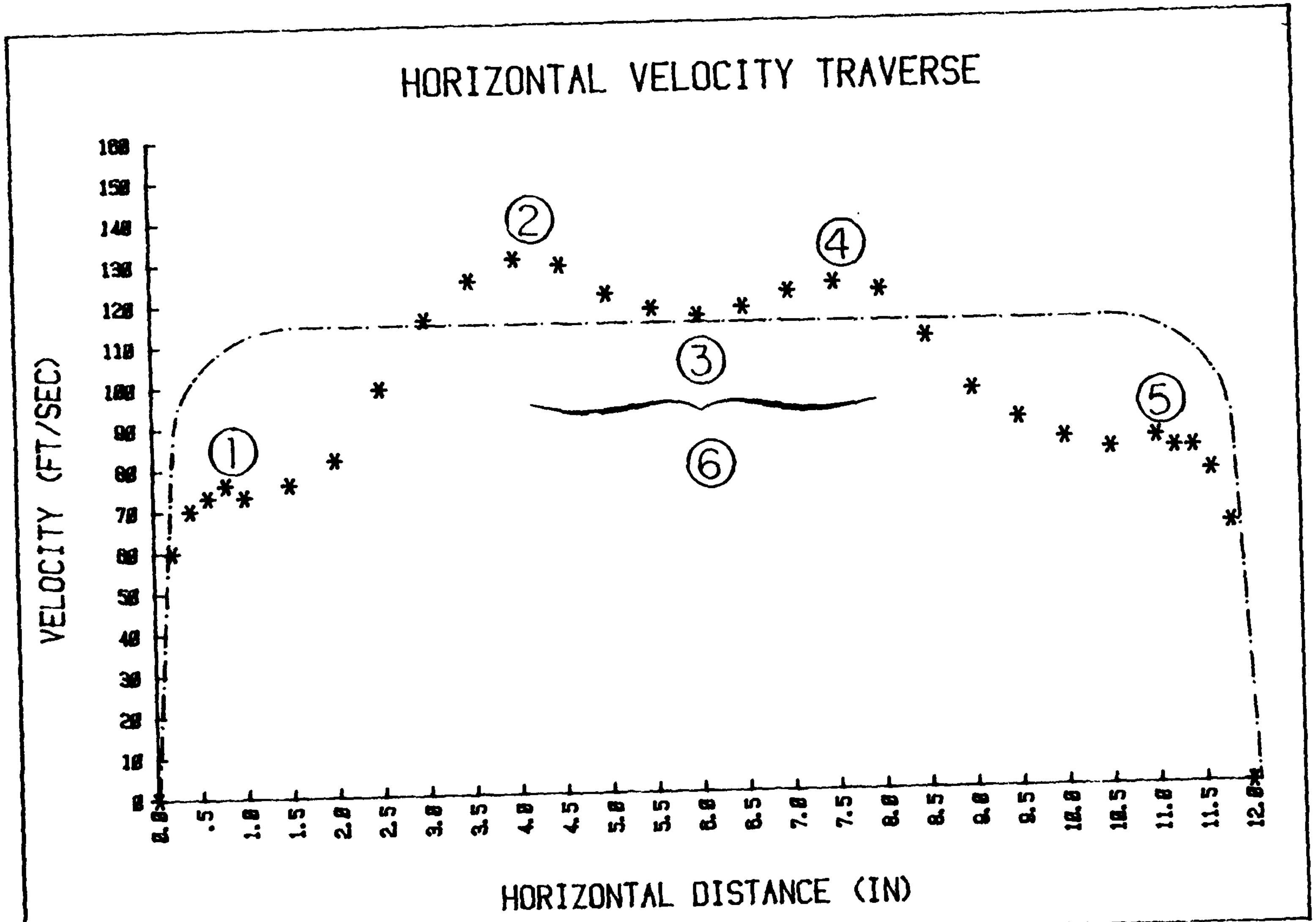


FIGURE 23 - SAMPLE HORIZONTAL VELOCITY PROFILE PLOT

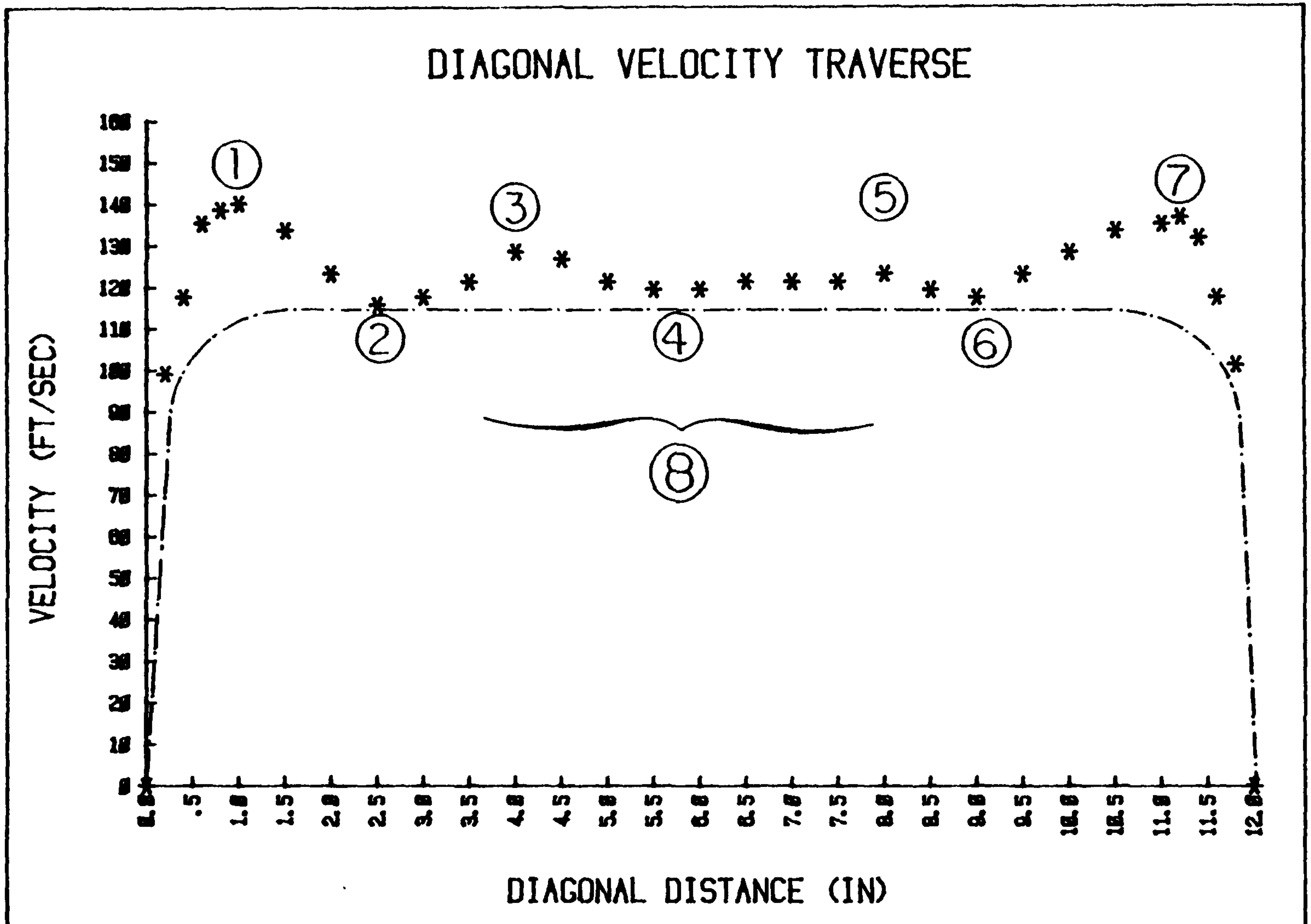
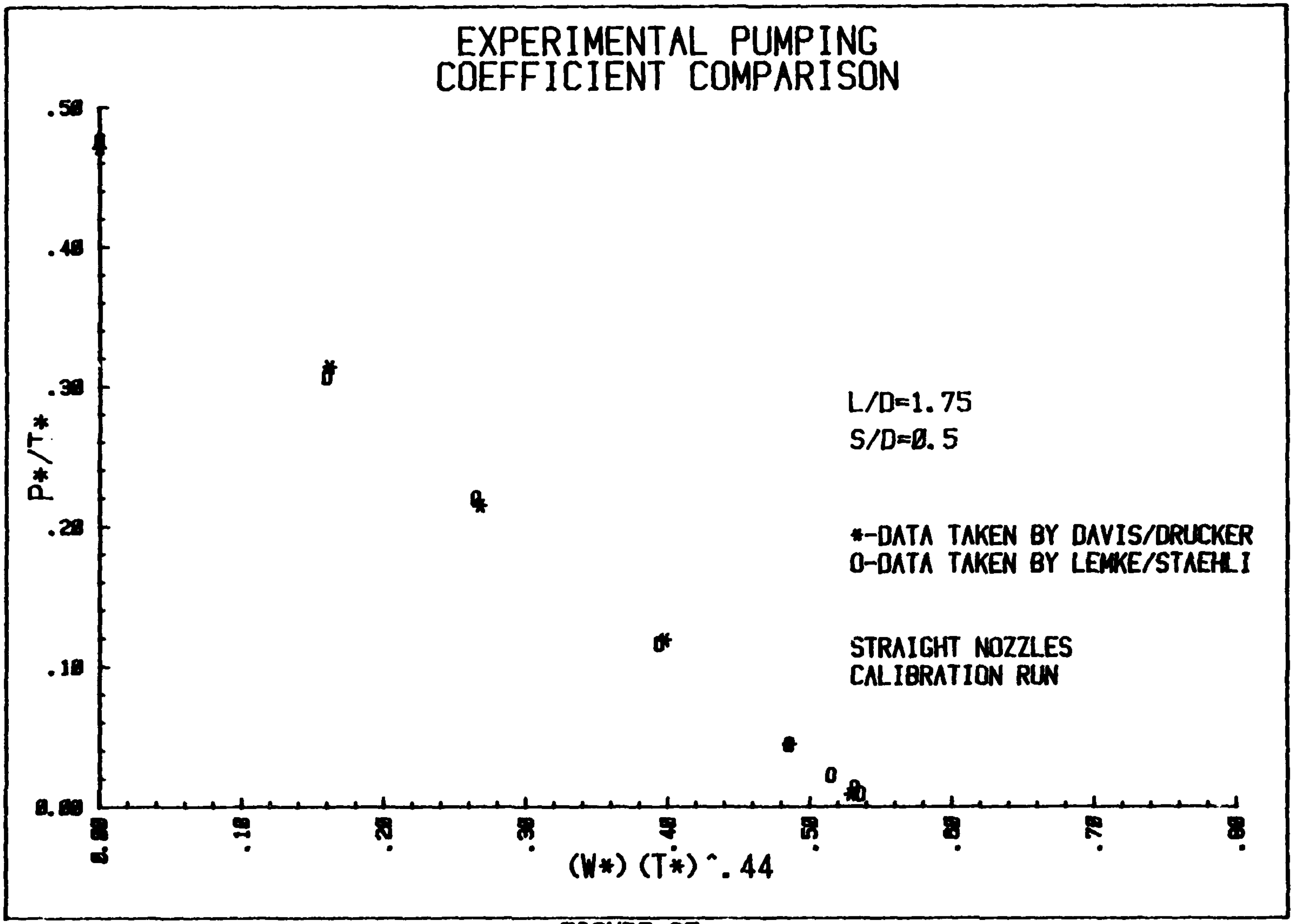
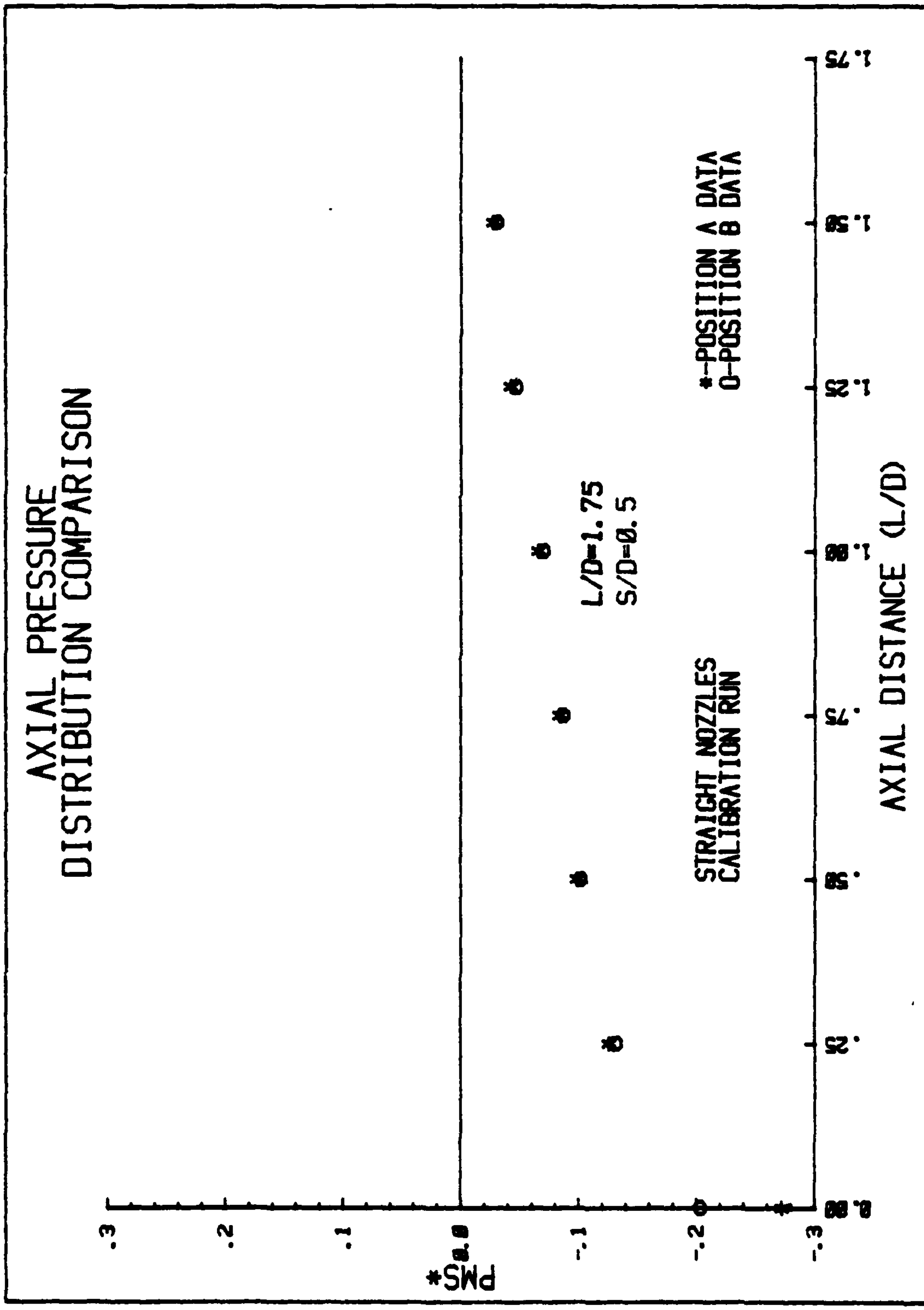


FIGURE 24 - SAMPLE DIAGONAL VELOCITY PROFILE PLOT



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
L/D=1.75
S/D=Ø.5
*-DATA TAKEN BY DAVIS/DRUCKER
O-DATA TAKEN BY LEMKE/STAEHLI
STRAIGHT NOZZLES
CALIBRATION RUN

FIGURE 25



AXIAL PRESSURE
DISTRIBUTION COMPARISON
L/D=1.75
S/D=Ø.5
STRAIGHT NOZZLES
CALIBRATION RUN
*-POSITION A DATA
O-POSITION B DATA
PMS*
.3
.2
.1
Ø.Ø
-.1
-.2
-.3
Ø.ØØ
.25
.5Ø
.75
1.ØØ
1.25
1.5Ø
1.75
AXIAL DISTANCE (L/D)

FIGURE 25.1

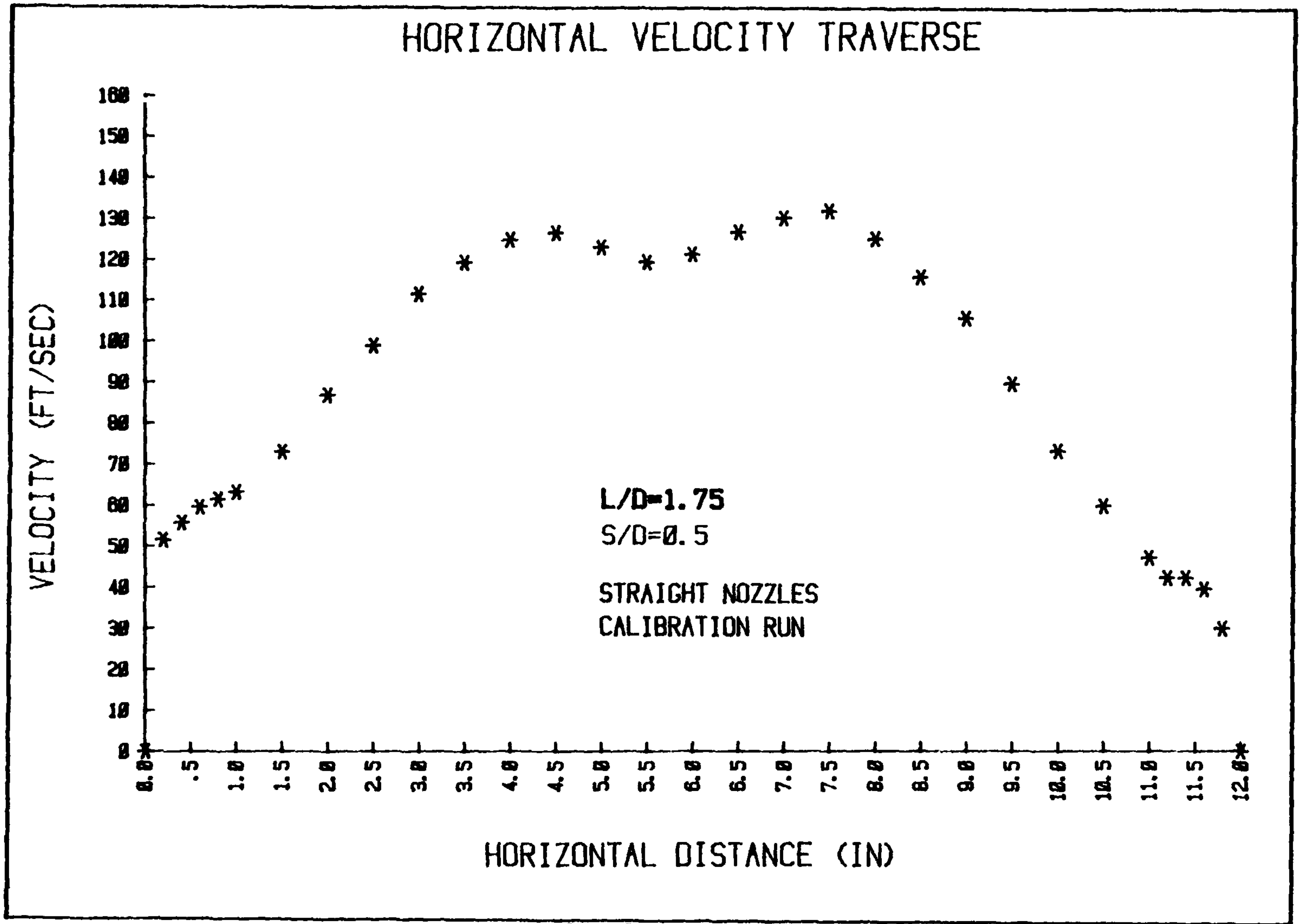

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
HORIZONTAL DISTANCE (IN)
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
L/D=1.75
S/D=0.5
STRAIGHT NOZZLES
CALIBRATION RUN

FIGURE 25.2

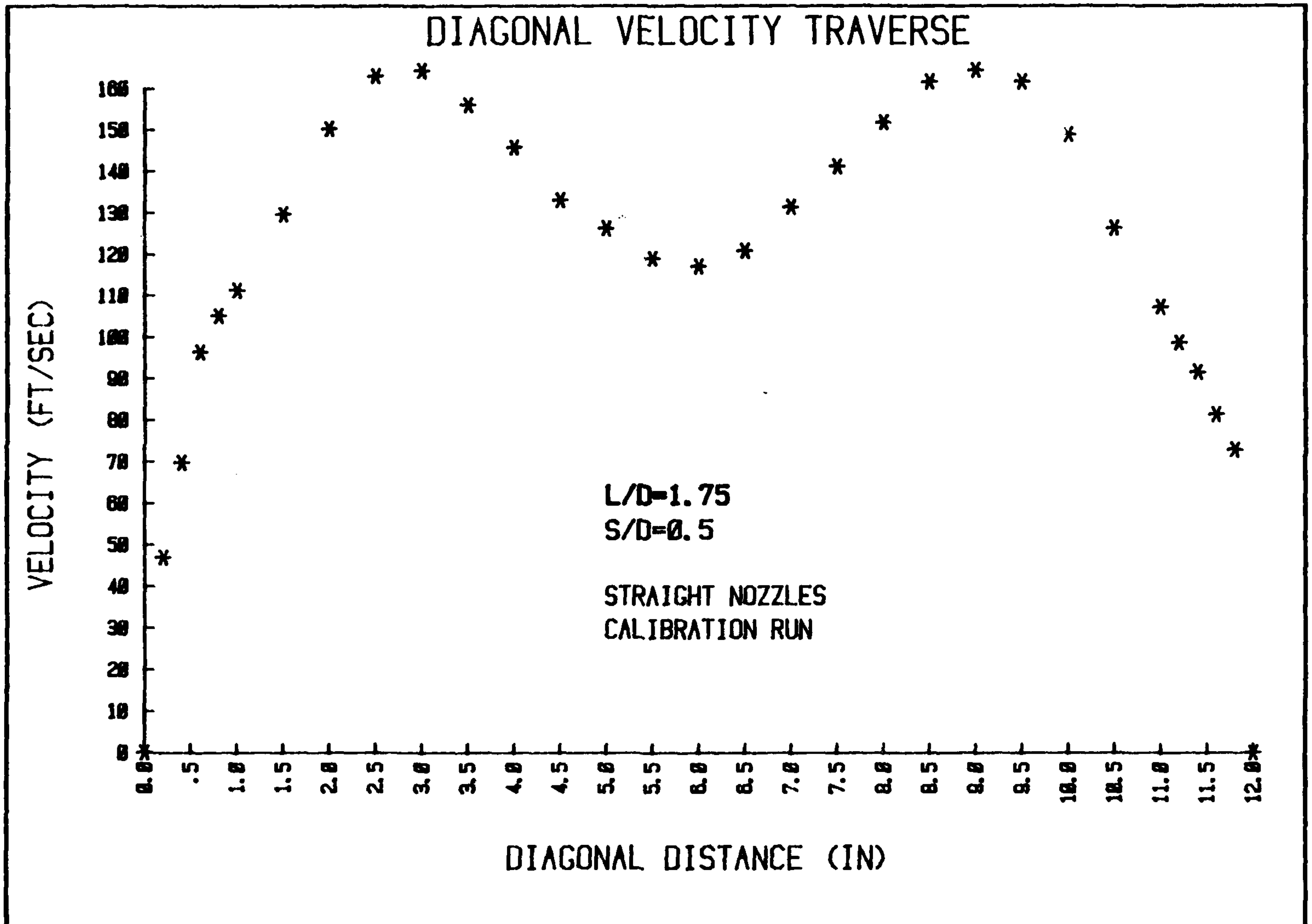

DIAGONAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)
L/D=1.75
S/D=0.5
STRAIGHT NOZZLES
CALIBRATION RUN

FIGURE 25.3

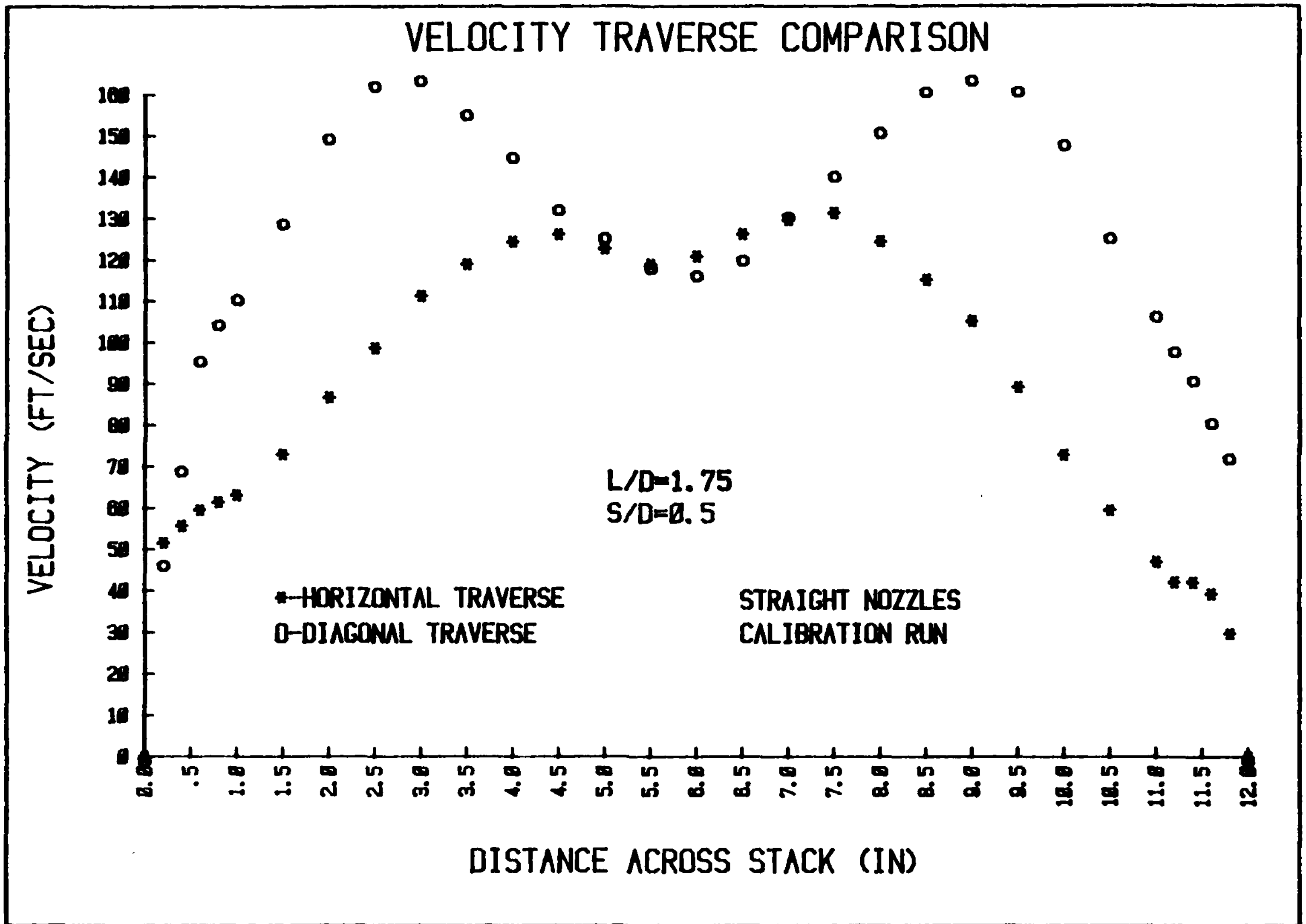

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
L/D=1.75
S/D=Ø.5
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
STRAIGHT NOZZLES
CALIBRATION RUN

FIGURE 25.4

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON

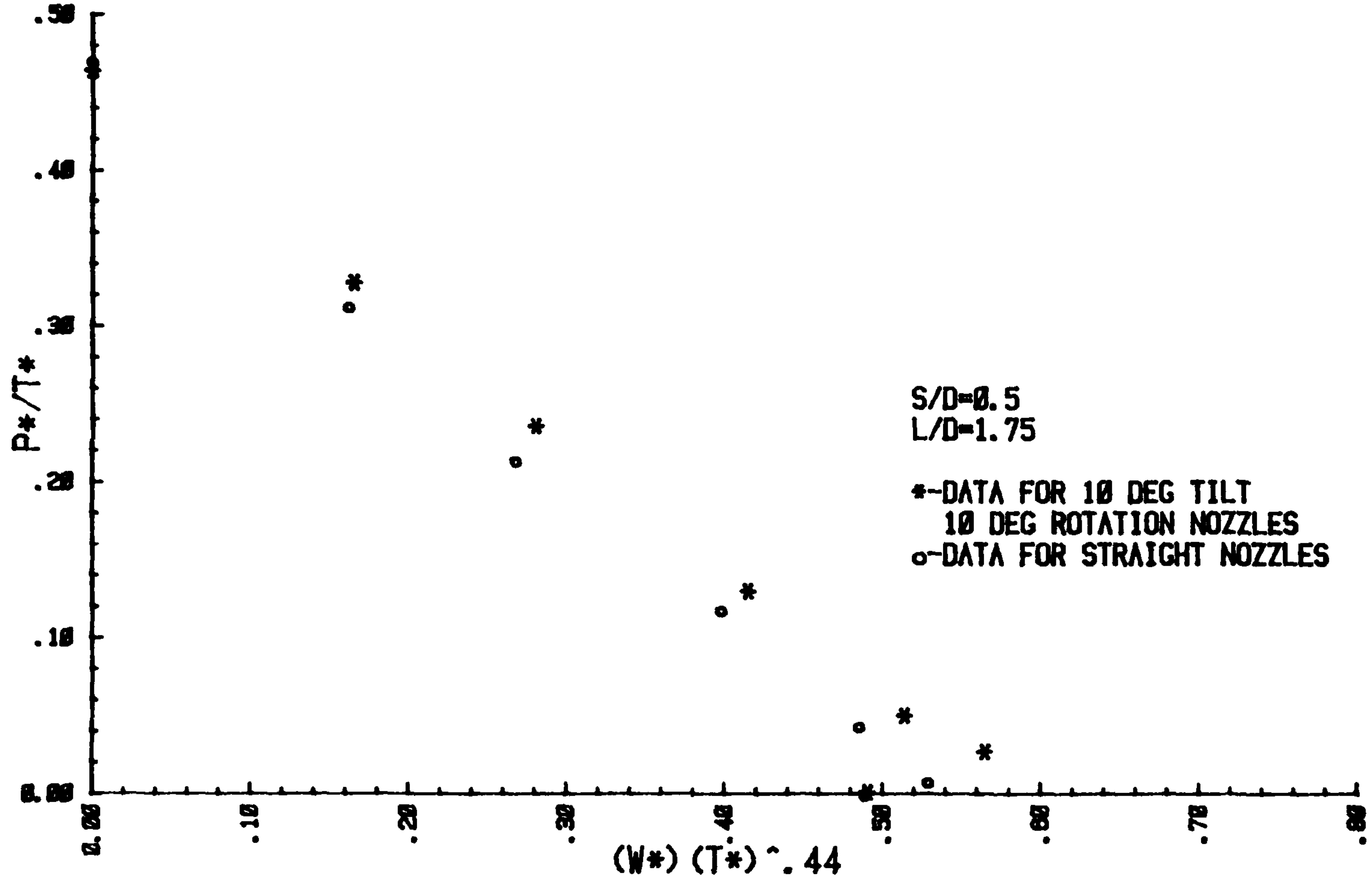


FIGURE 28

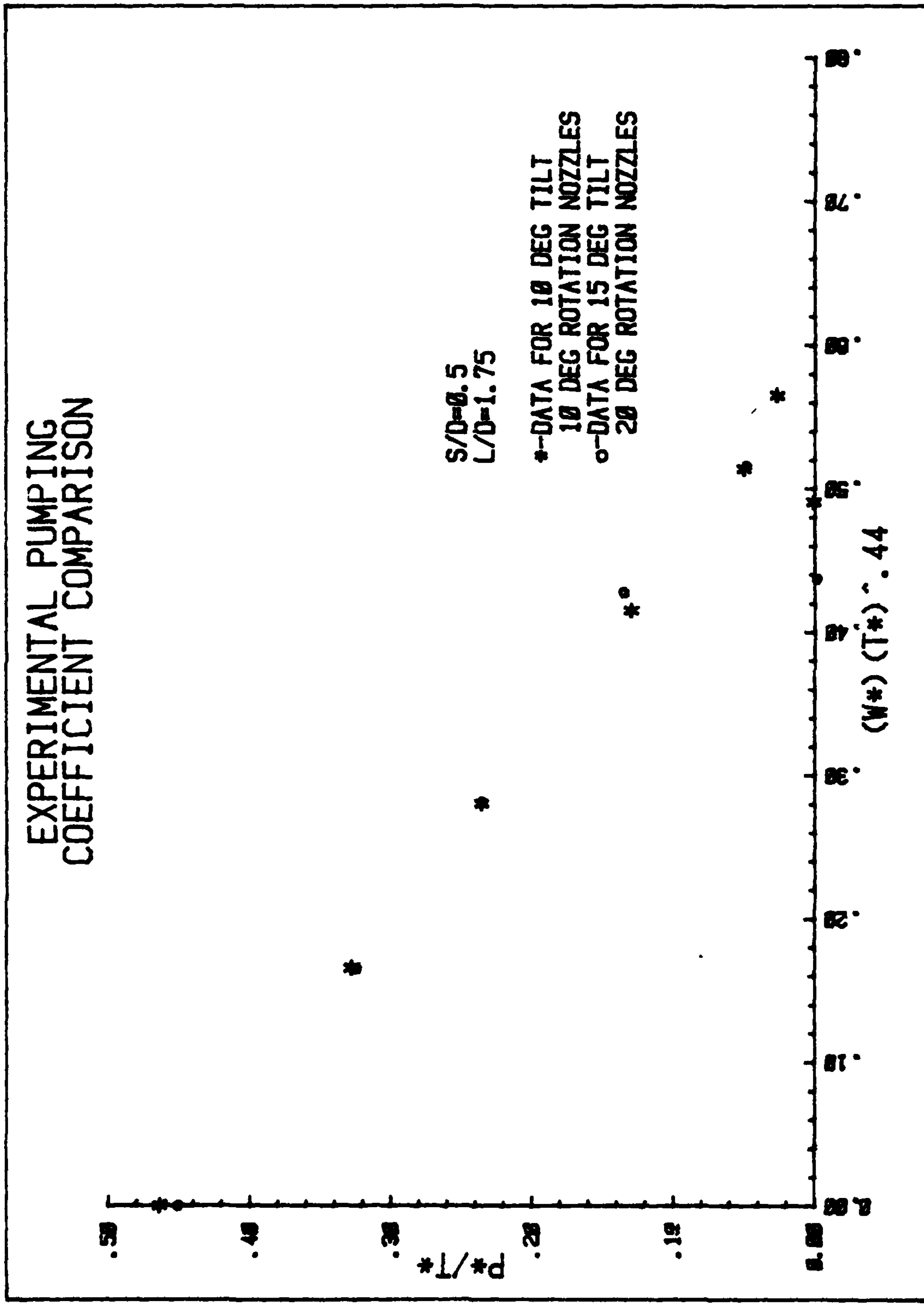

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 26.1

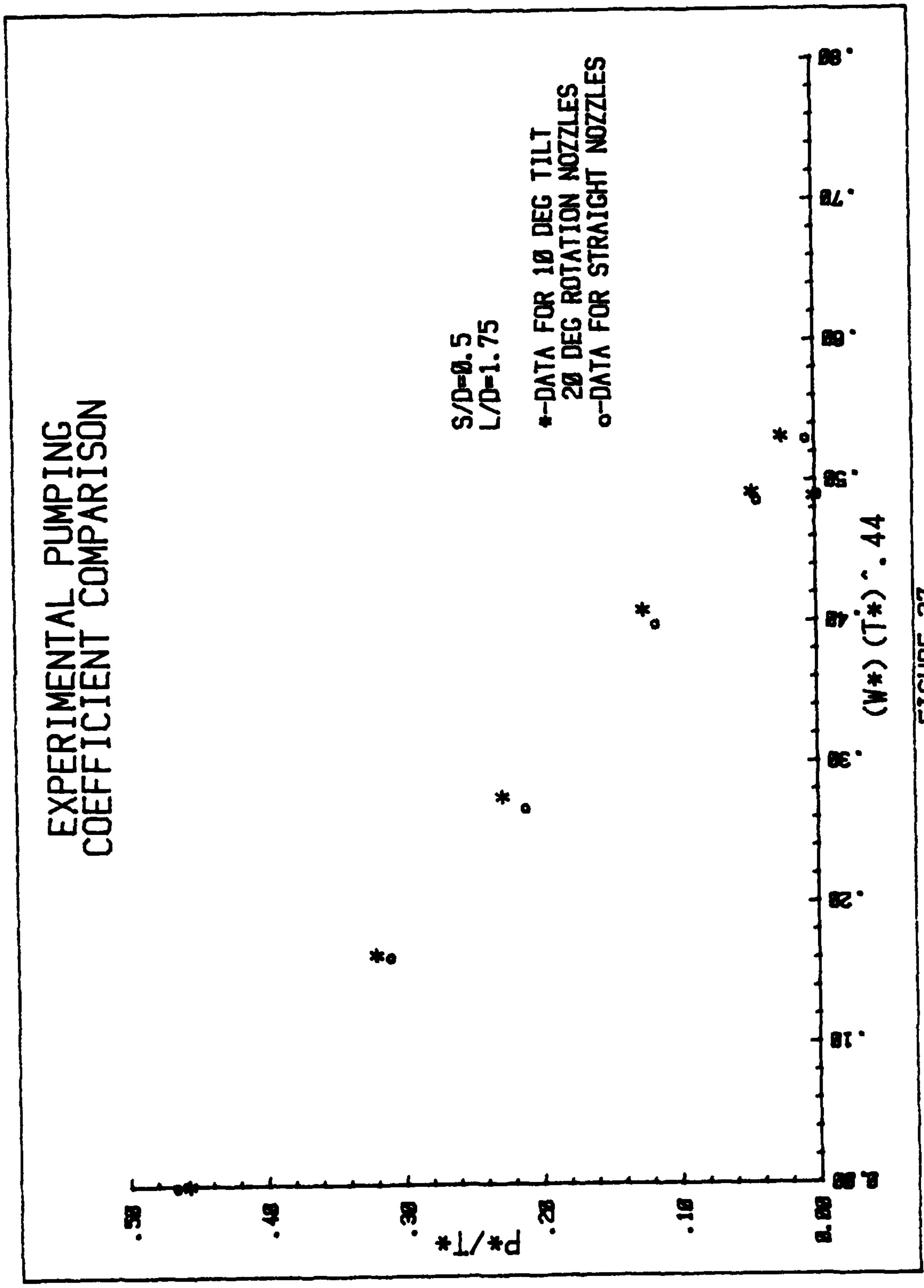
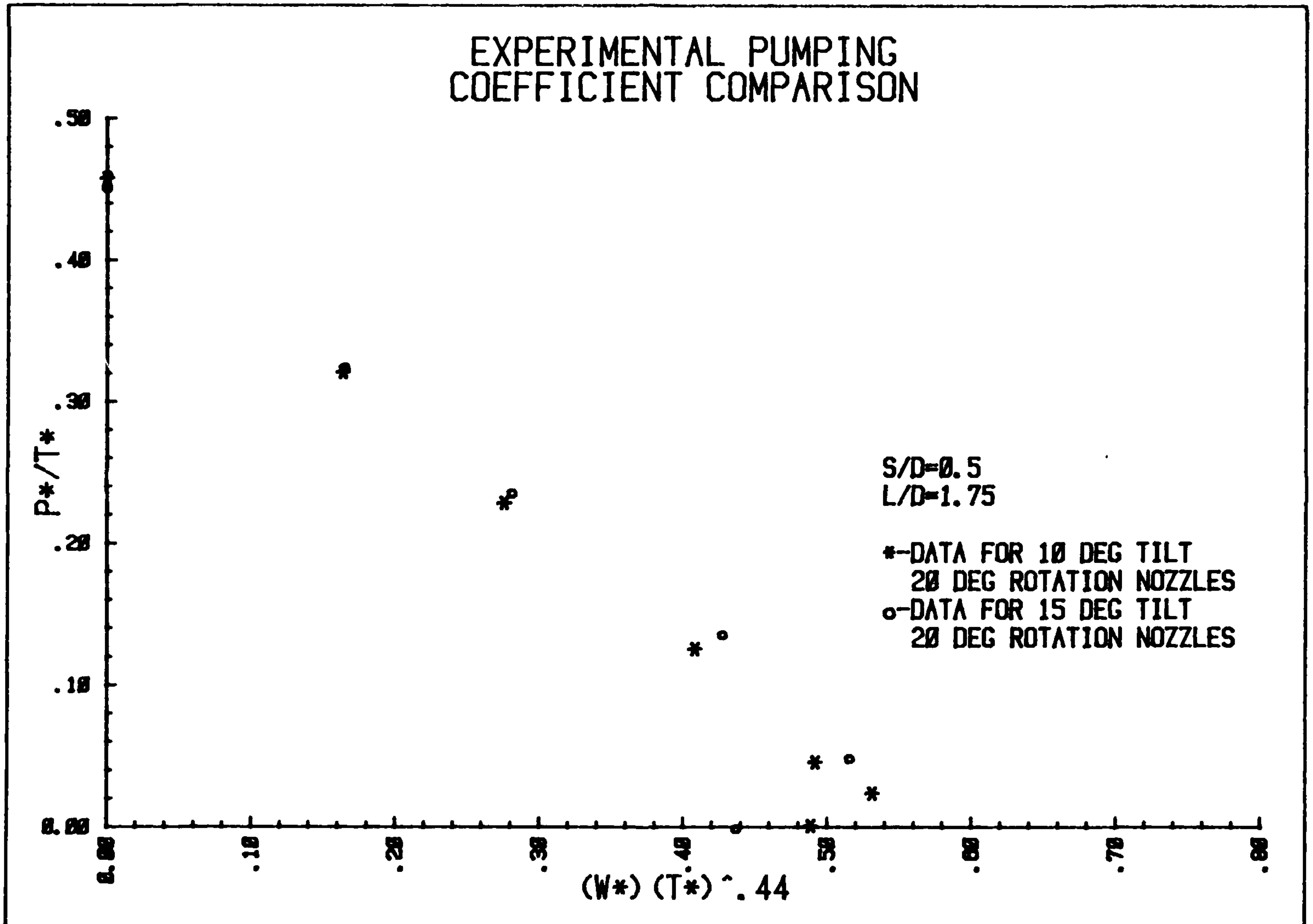

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 27


EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
FIGURE 27.1

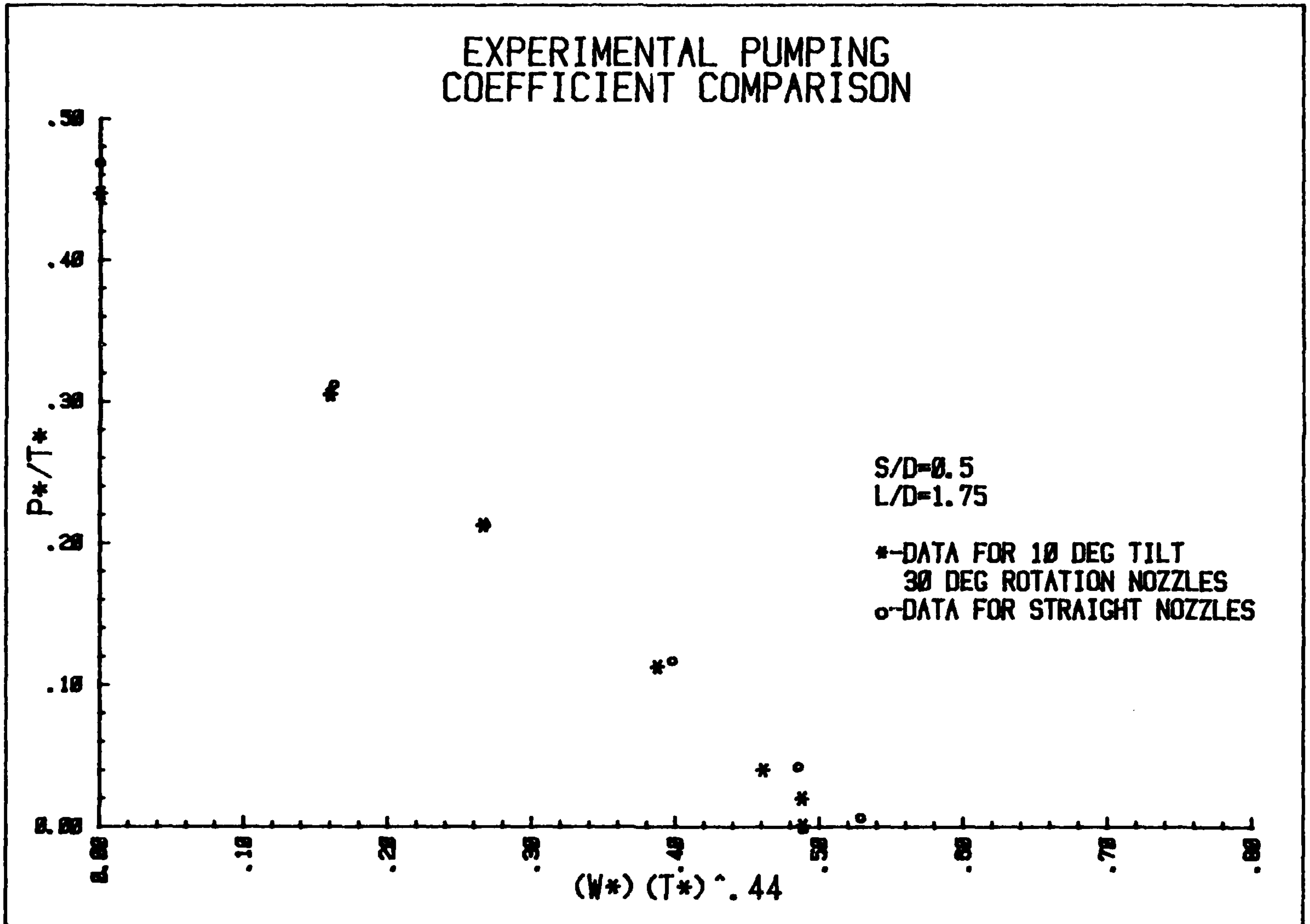

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 28

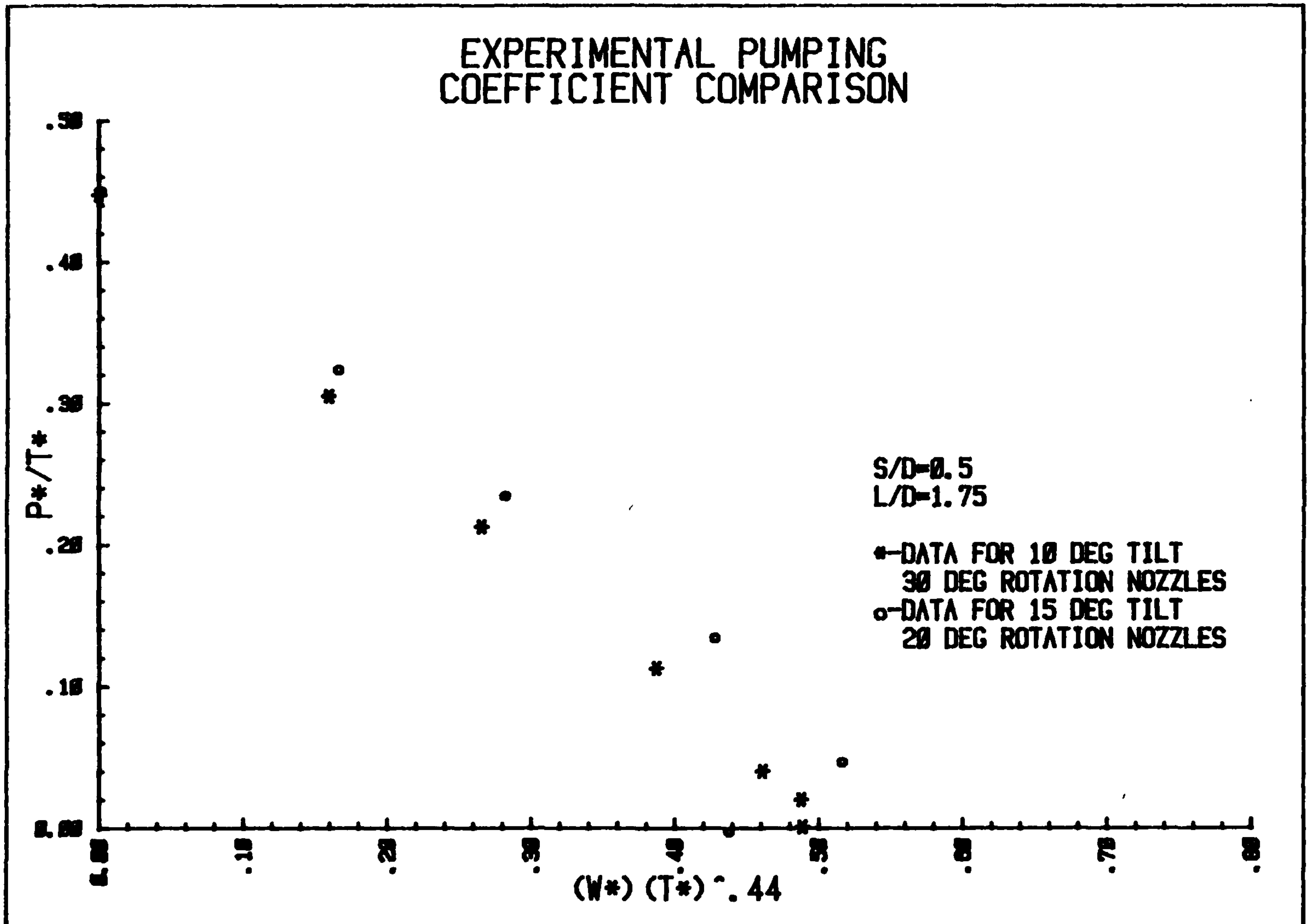

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 28.1

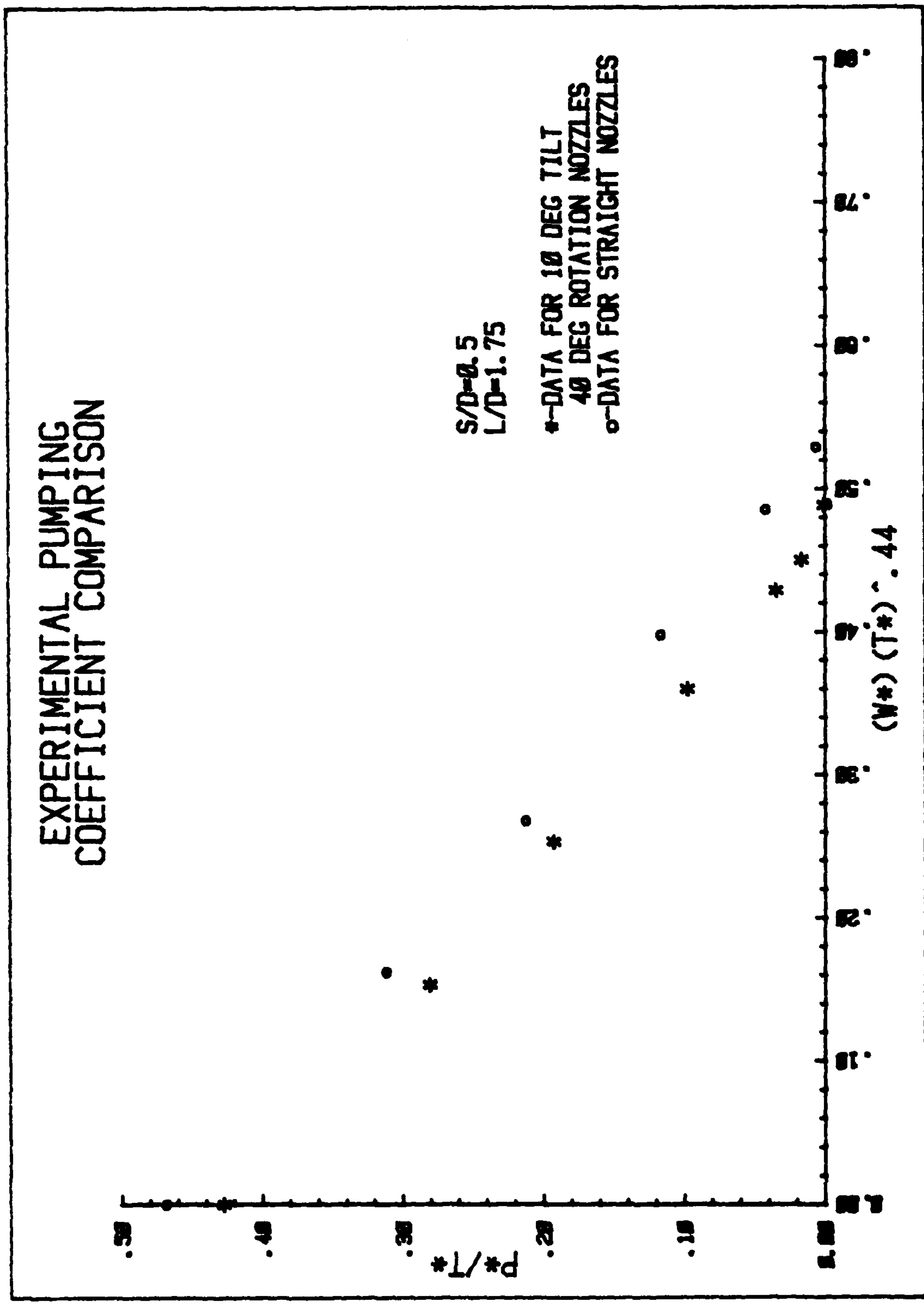
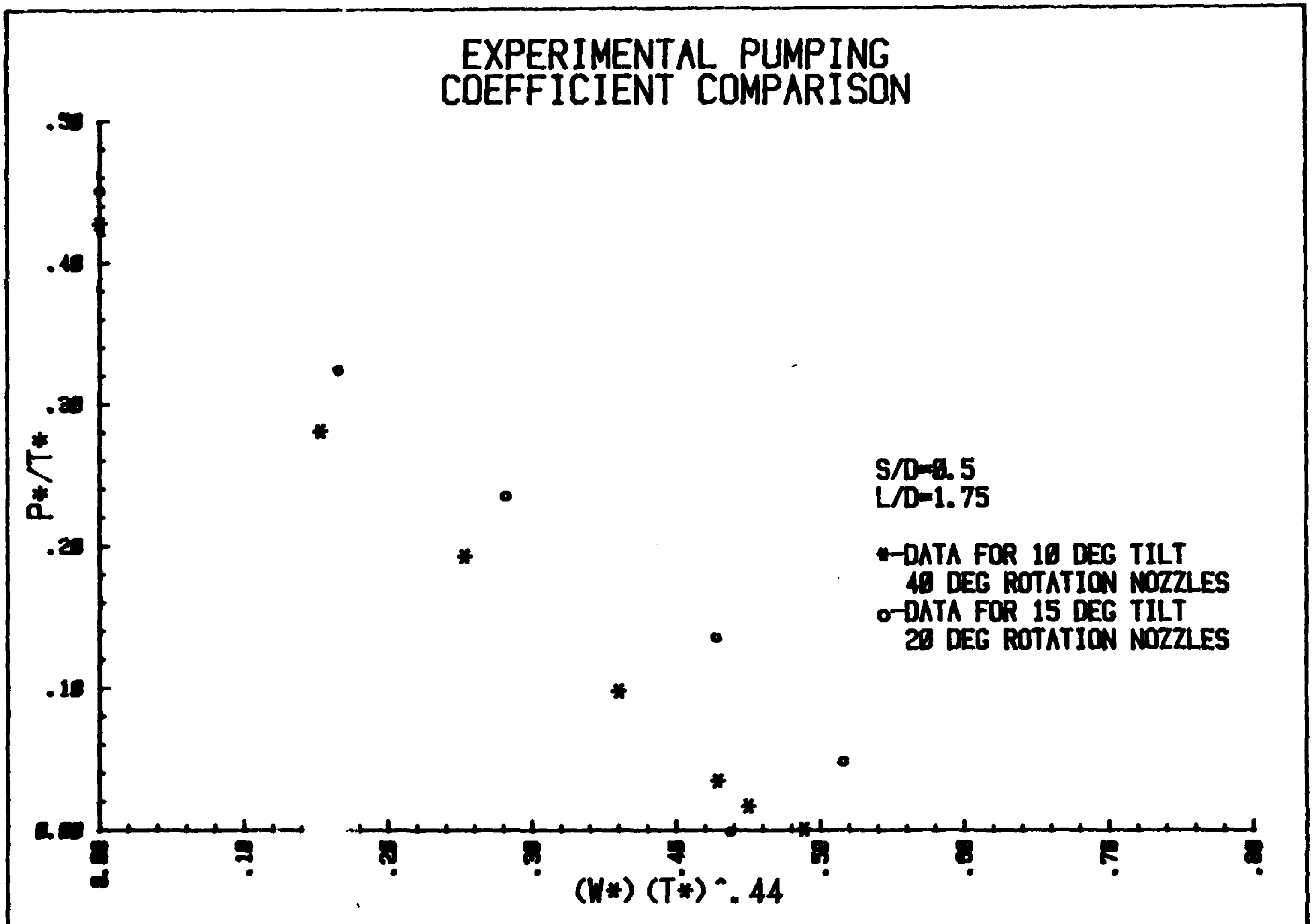

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 29



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 29.1

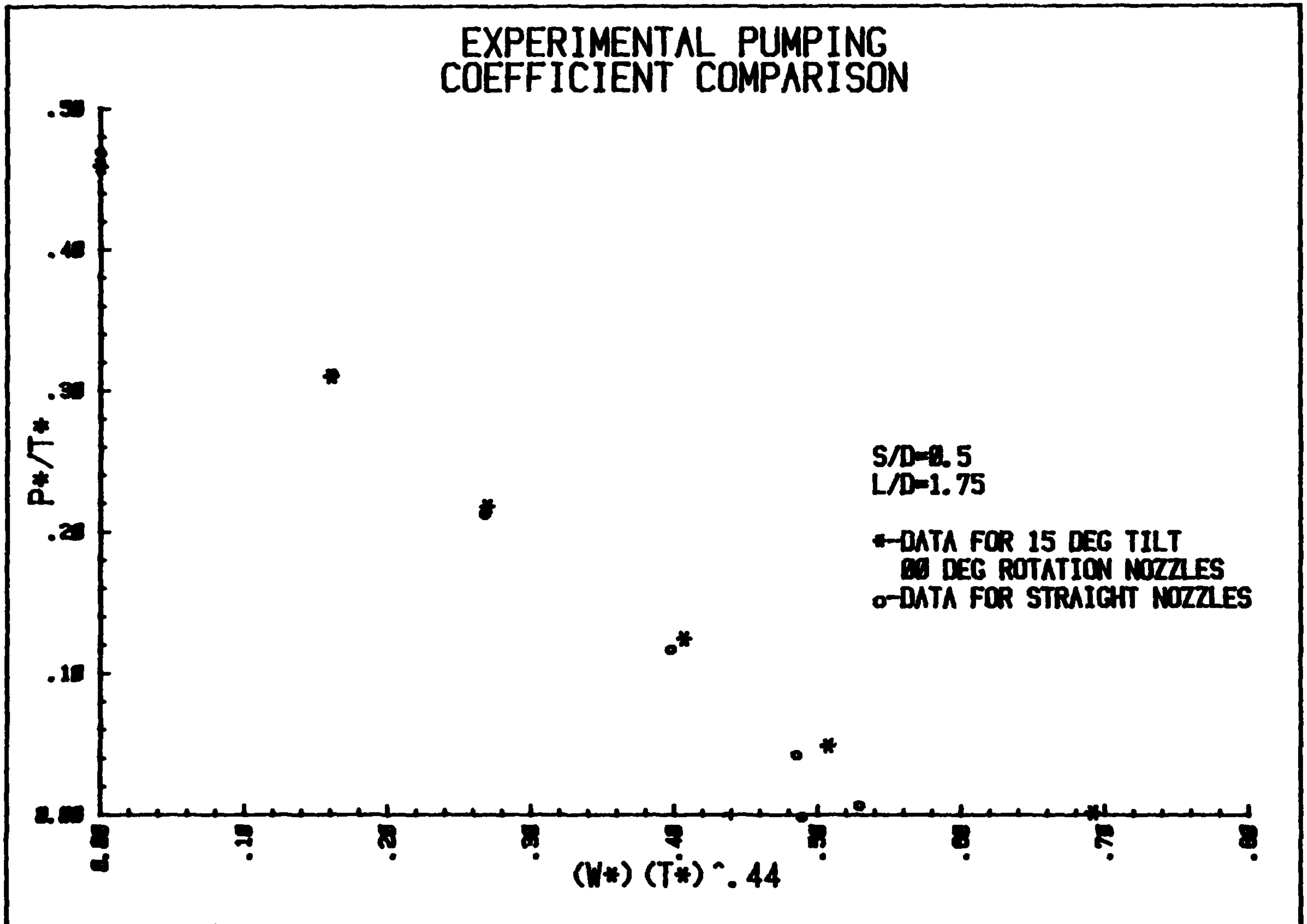

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
00 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 30

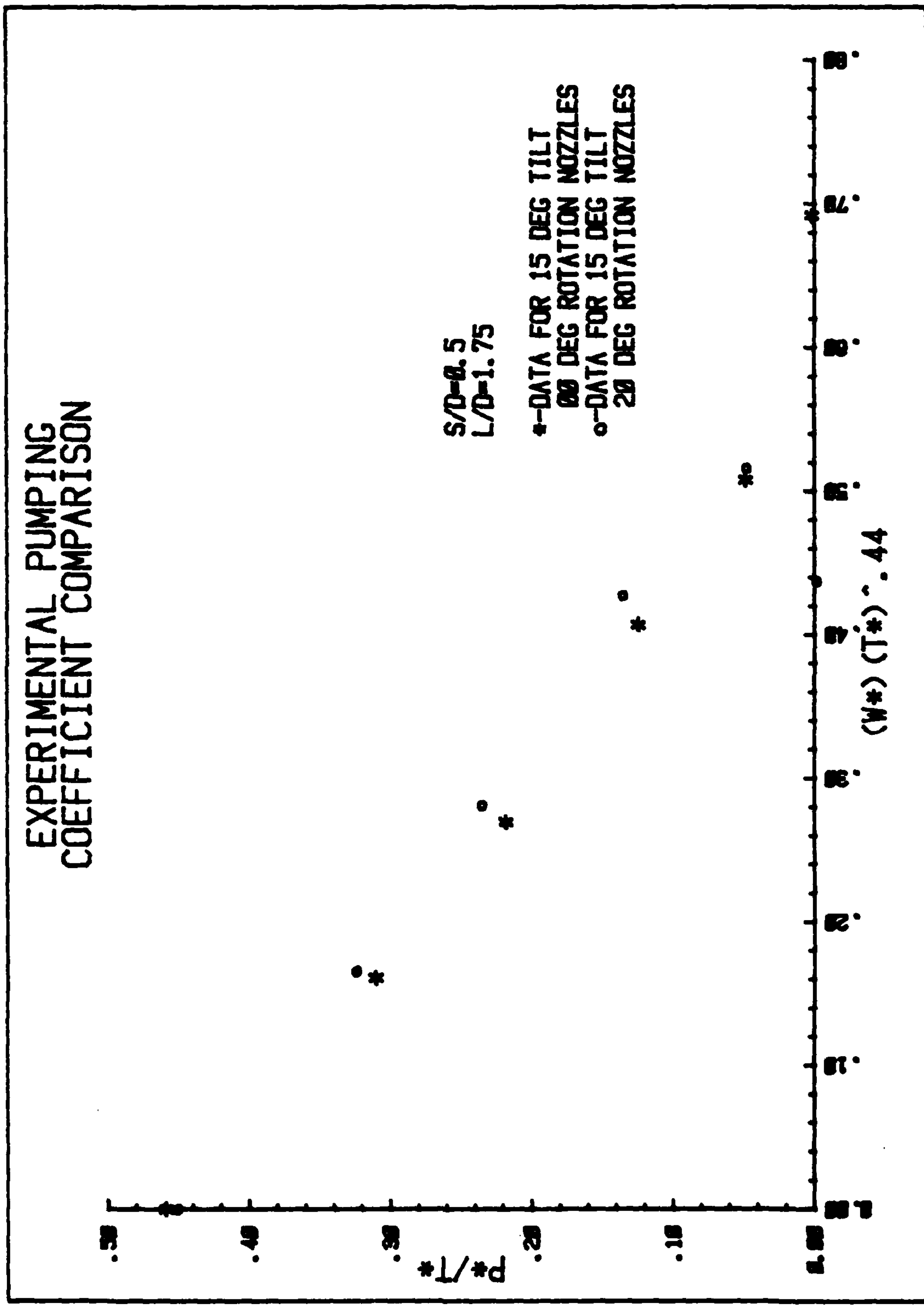

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
00 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
(W*)(T*)^.44
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 30.1

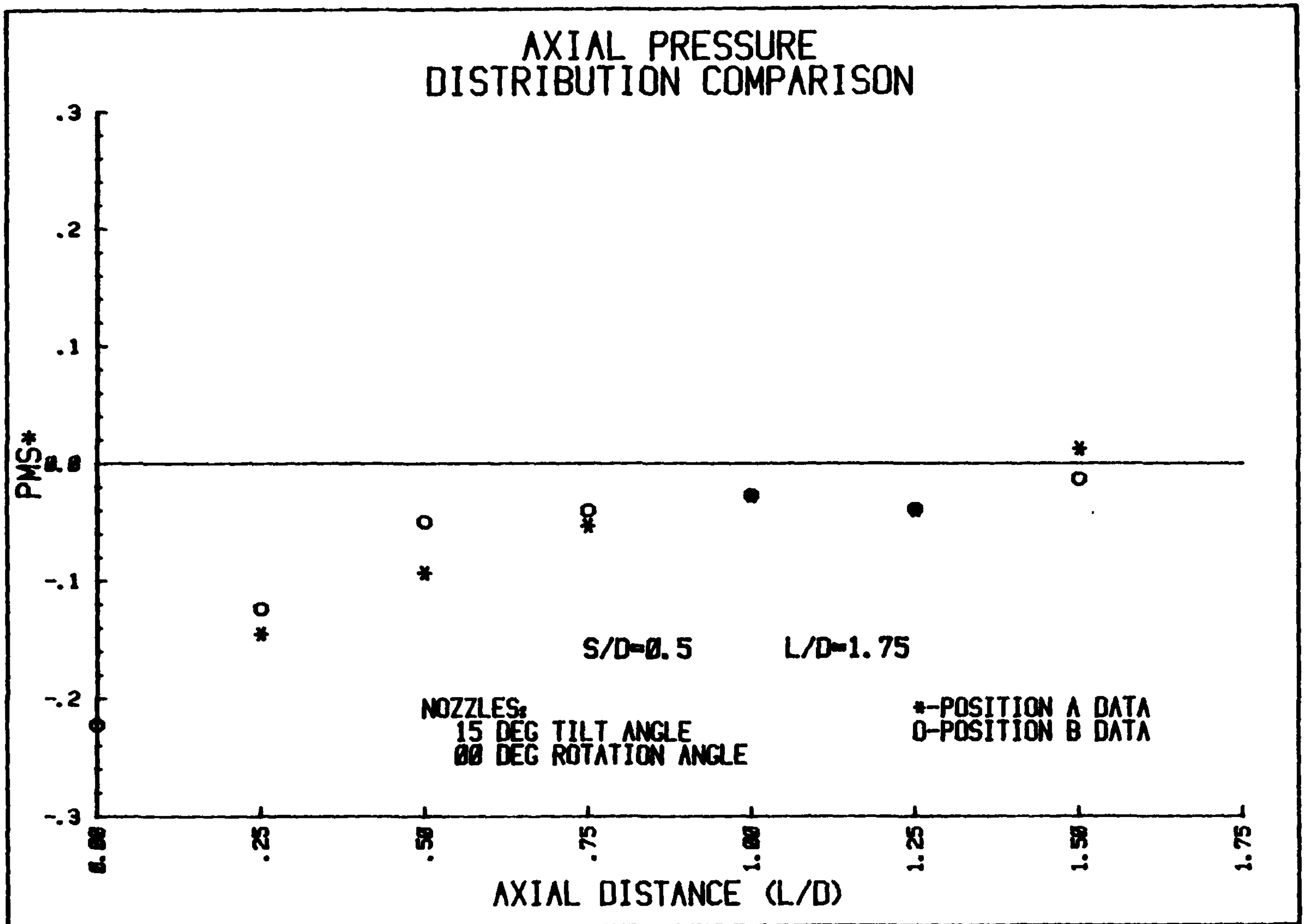
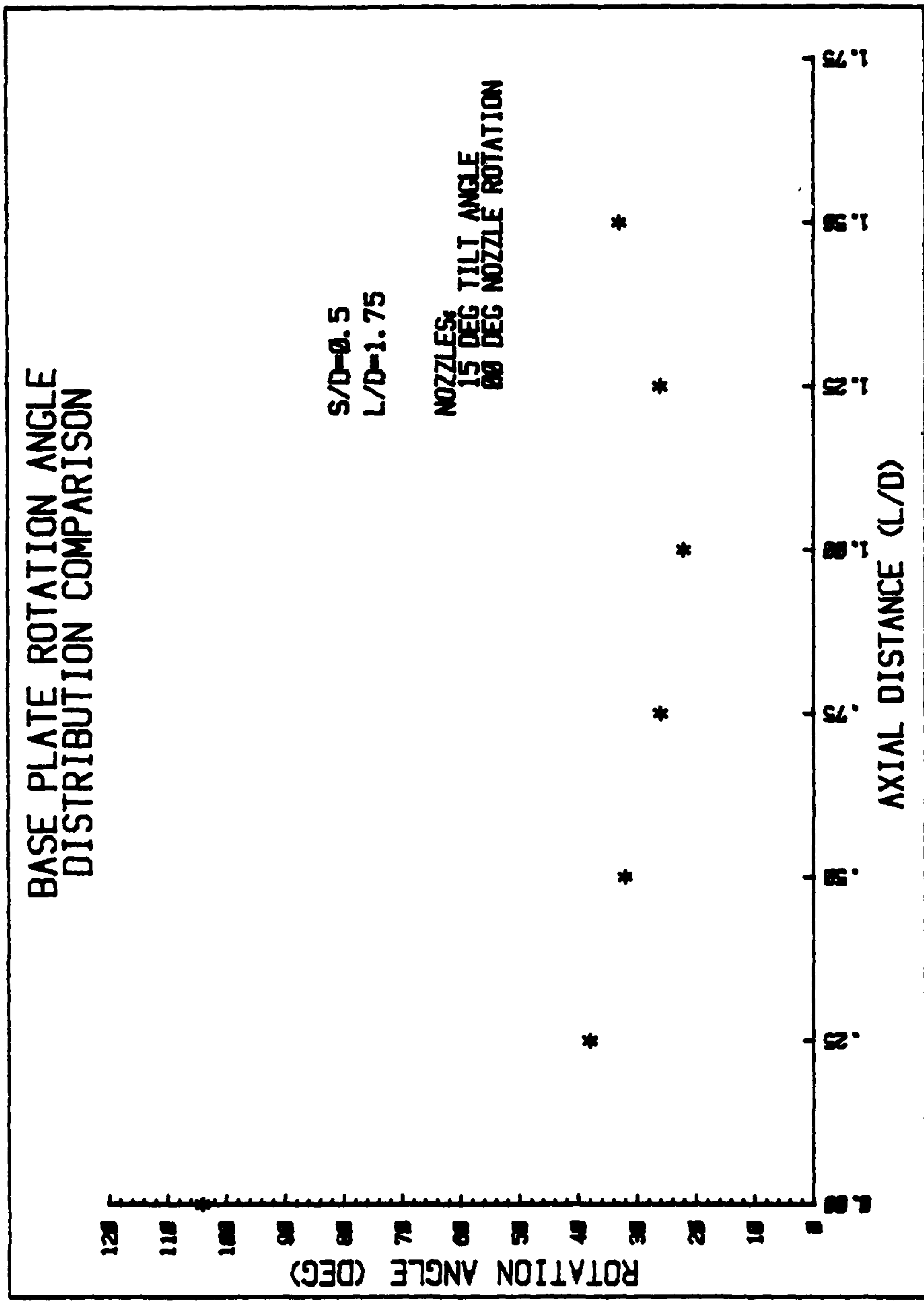

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
*-POSITION A DATA
O-POSITION B DATA

FIGURE 30.2


BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG NOZZLE ROTATION
ROTATION ANGLE (DEG)
AXIAL DISTANCE (L/D)
0
10
20
30
40
50
60
70
80
90
100
110
120
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
FIGURE 30.3

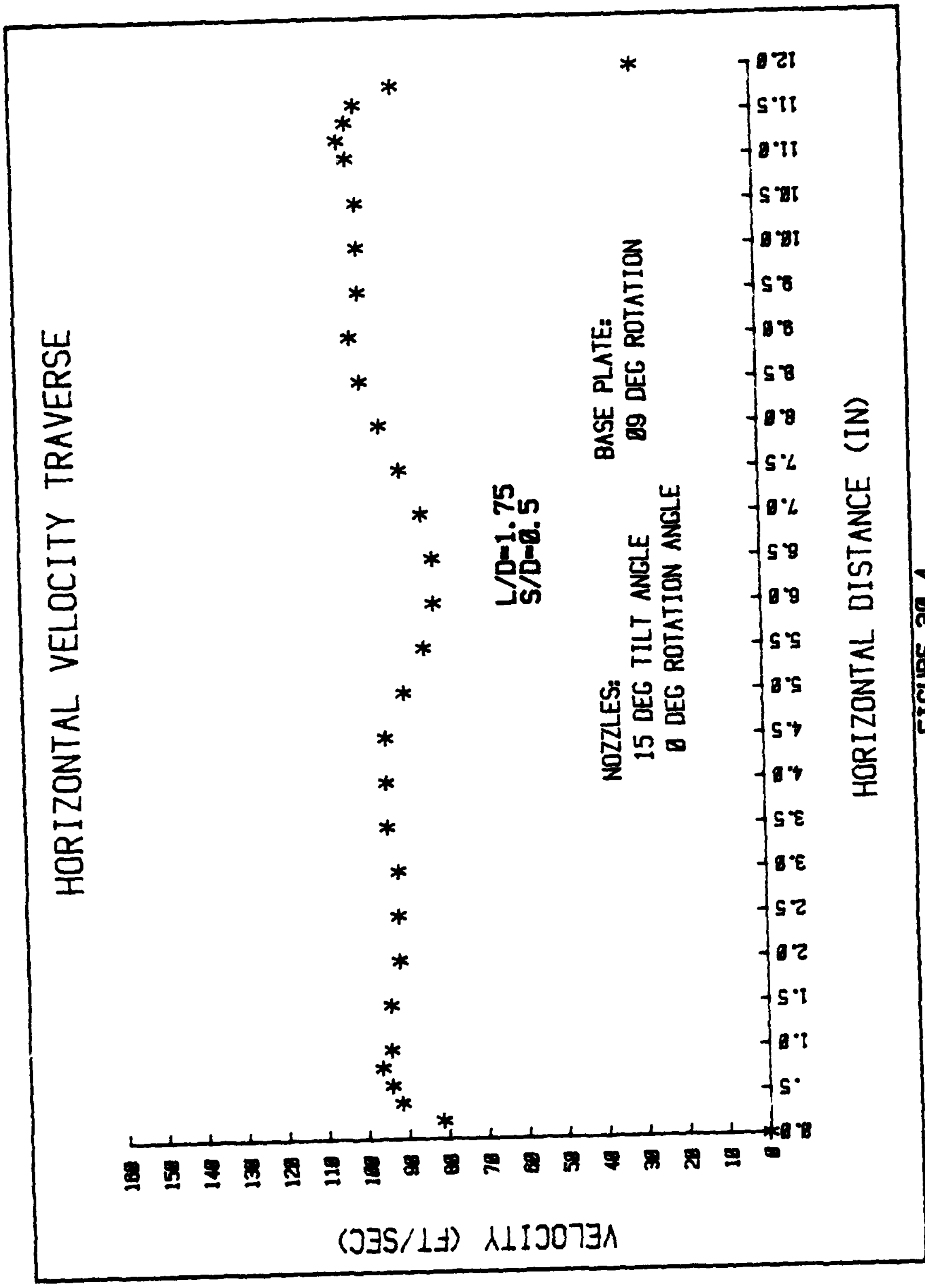

HORIZONTAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
0 DEG ROTATION ANGLE
BASE PLATE:
09 DEG ROTATION
HORIZONTAL DISTANCE (IN)
VELOCITY (FT/SEC)
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

FIGURE 30.4

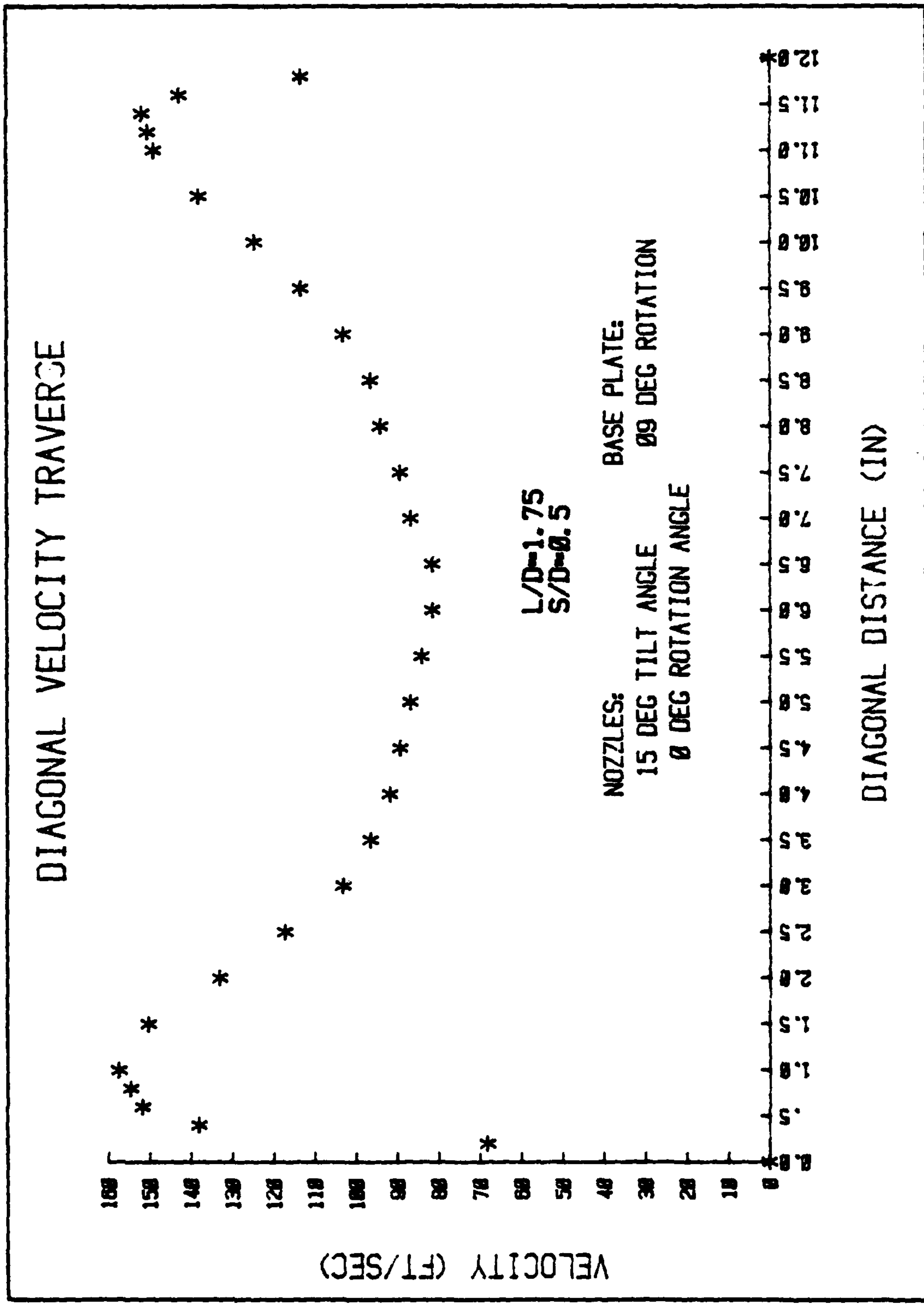

DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
0 DEG ROTATION ANGLE
BASE PLATE:
09 DEG ROTATION
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)

FIGURE 30.5

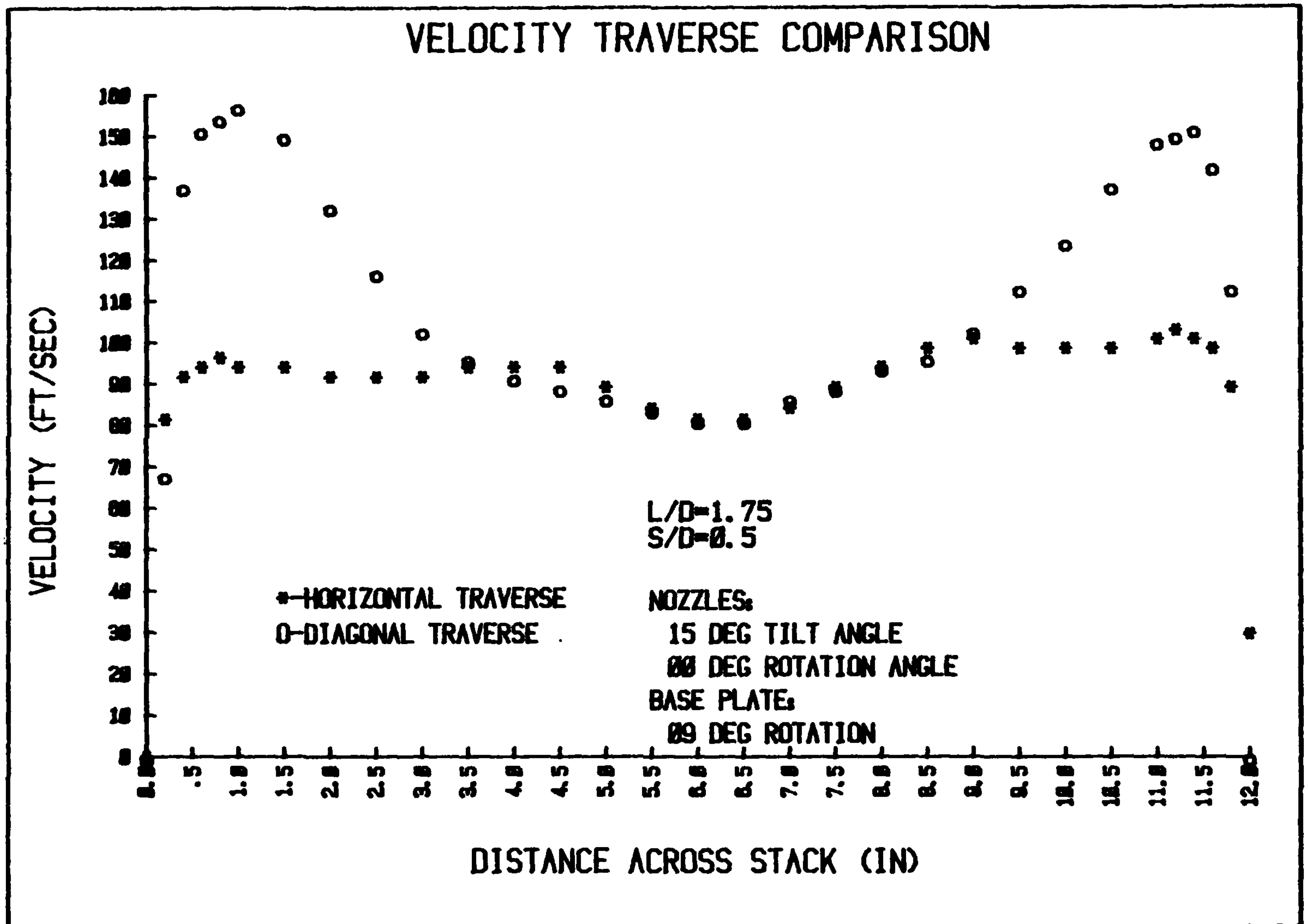
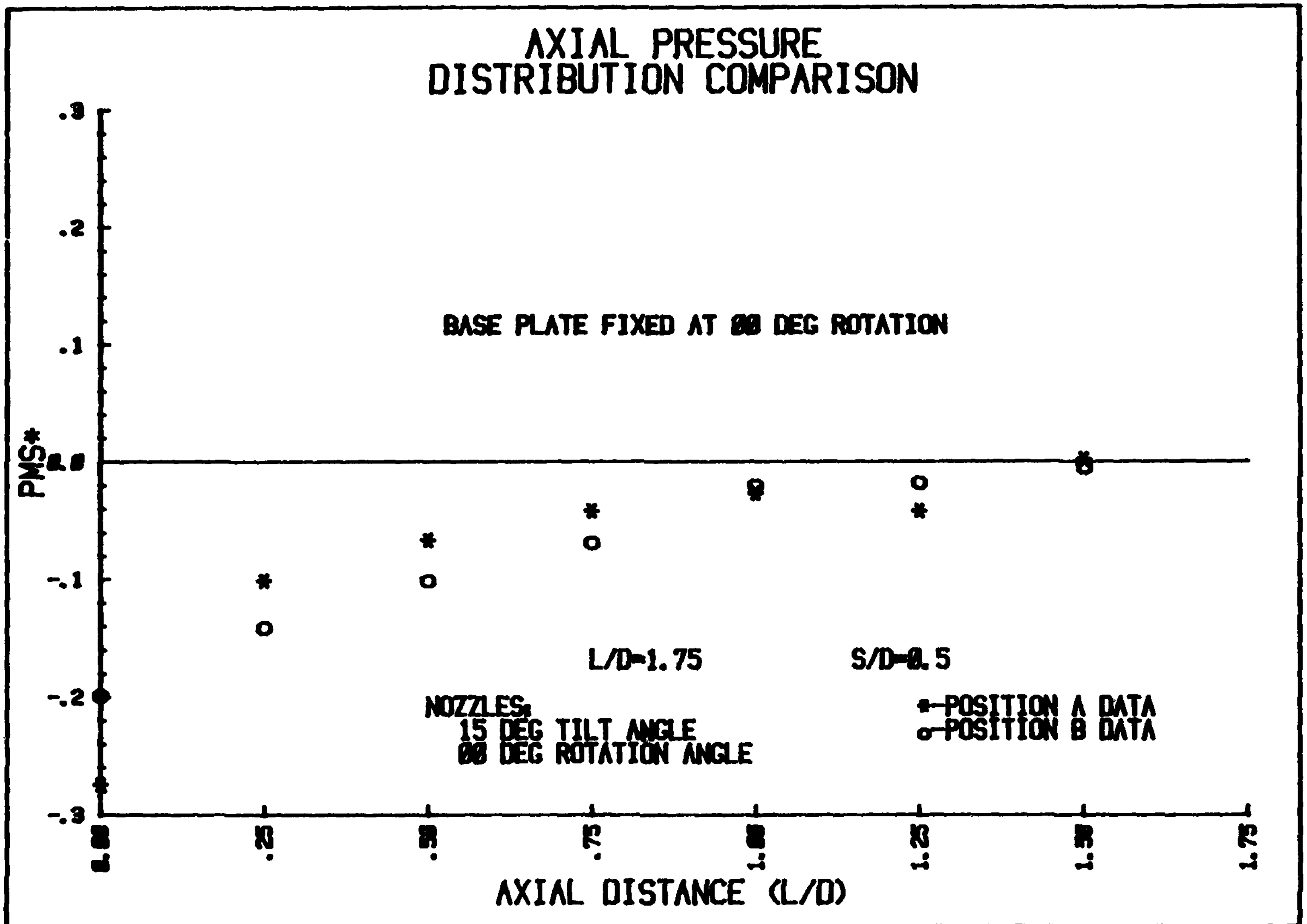

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
DISTANCE ACROSS STACK (IN)
L/D=1.75
S/D=0.5
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
BASE PLATE:
09 DEG ROTATION

FIGURE 30.6



AXIAL PRESSURE
DISTRIBUTION COMPARISON
BASE PLATE FIXED AT 00 DEG ROTATION
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 31

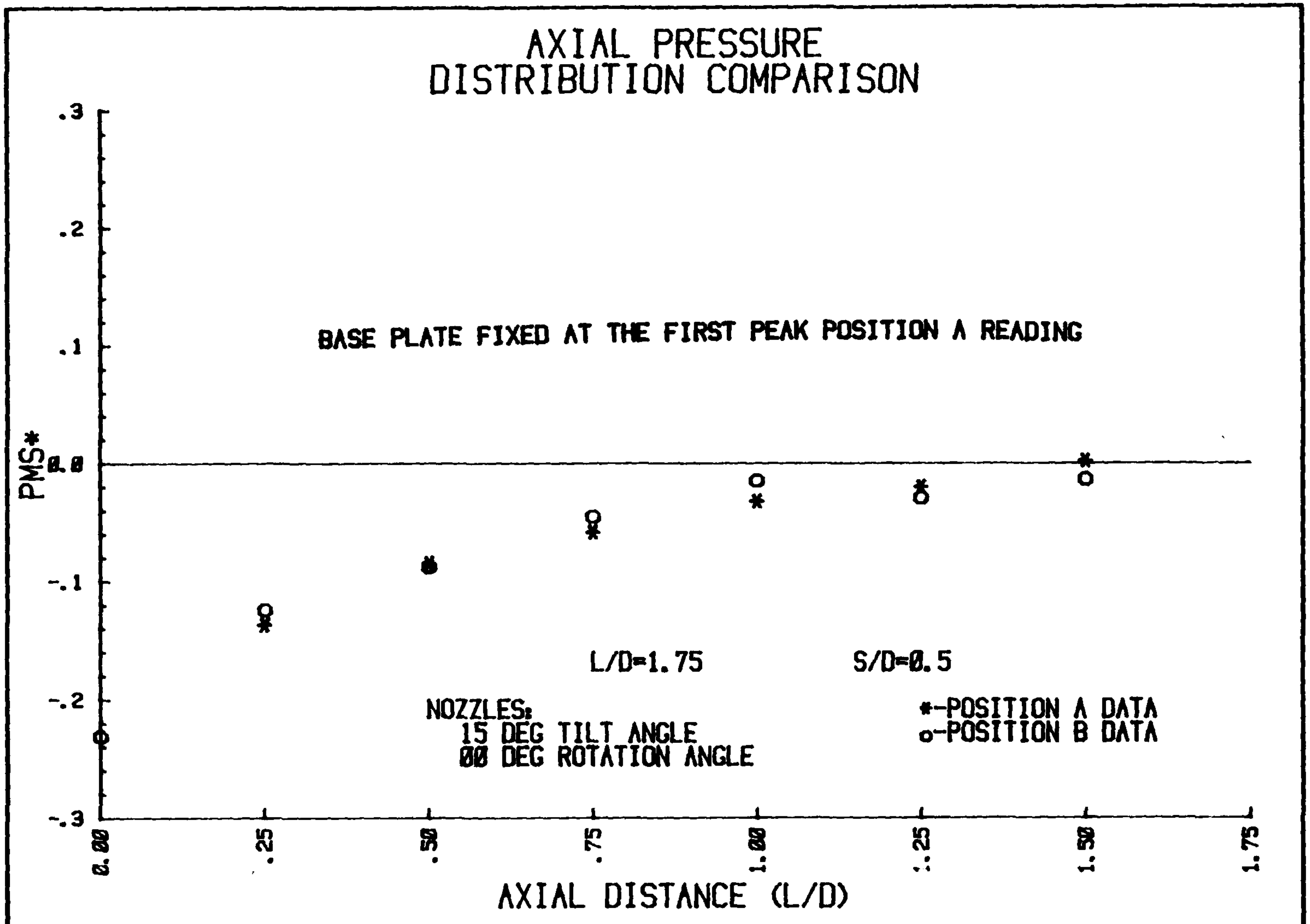

AXIAL PRESSURE
DISTRIBUTION COMPARISON
BASE PLATE FIXED AT THE FIRST PEAK POSITION A READING
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 32

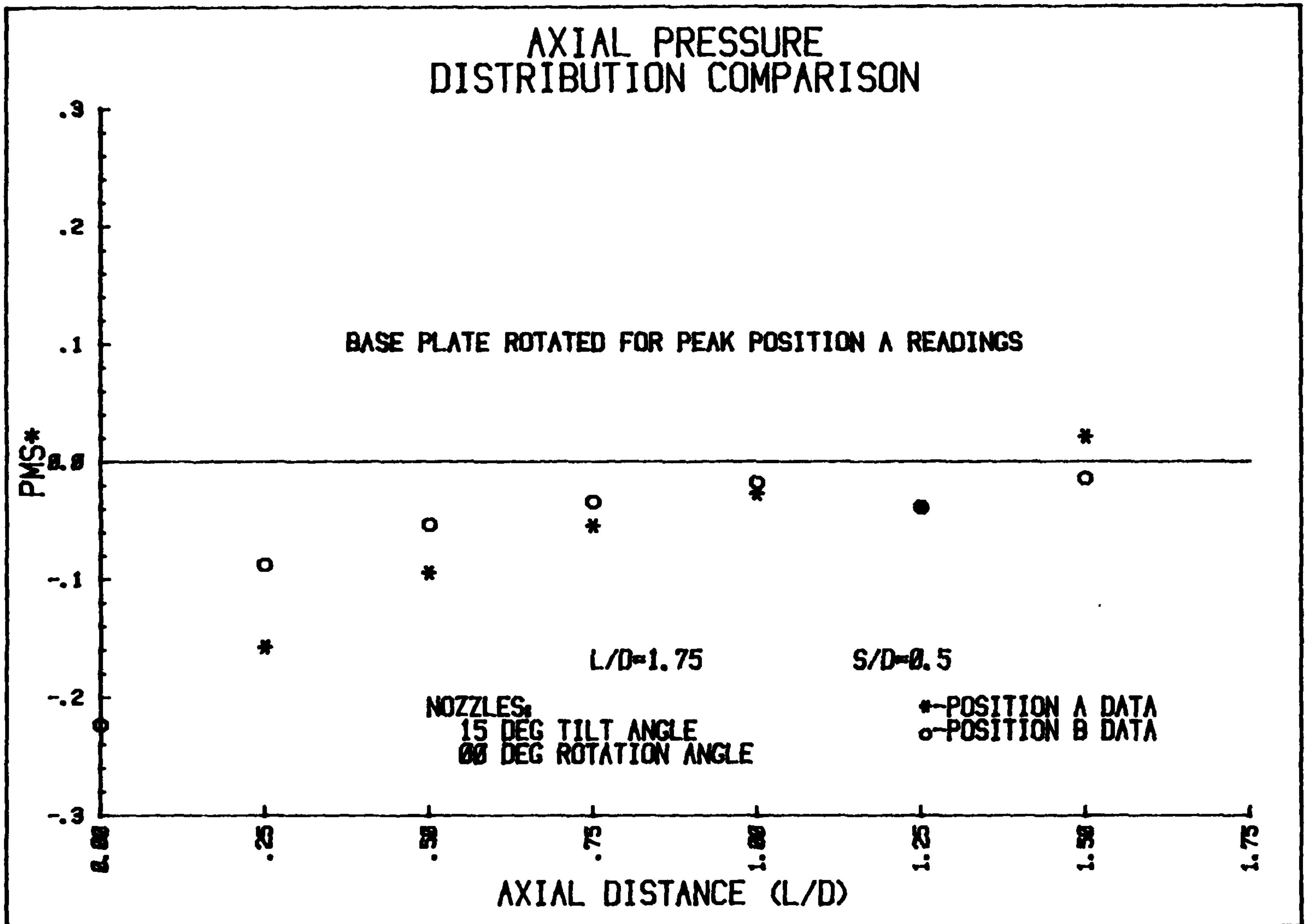

AXIAL PRESSURE
DISTRIBUTION COMPARISON
BASE PLATE ROTATED FOR PEAK POSITION A READINGS
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 33

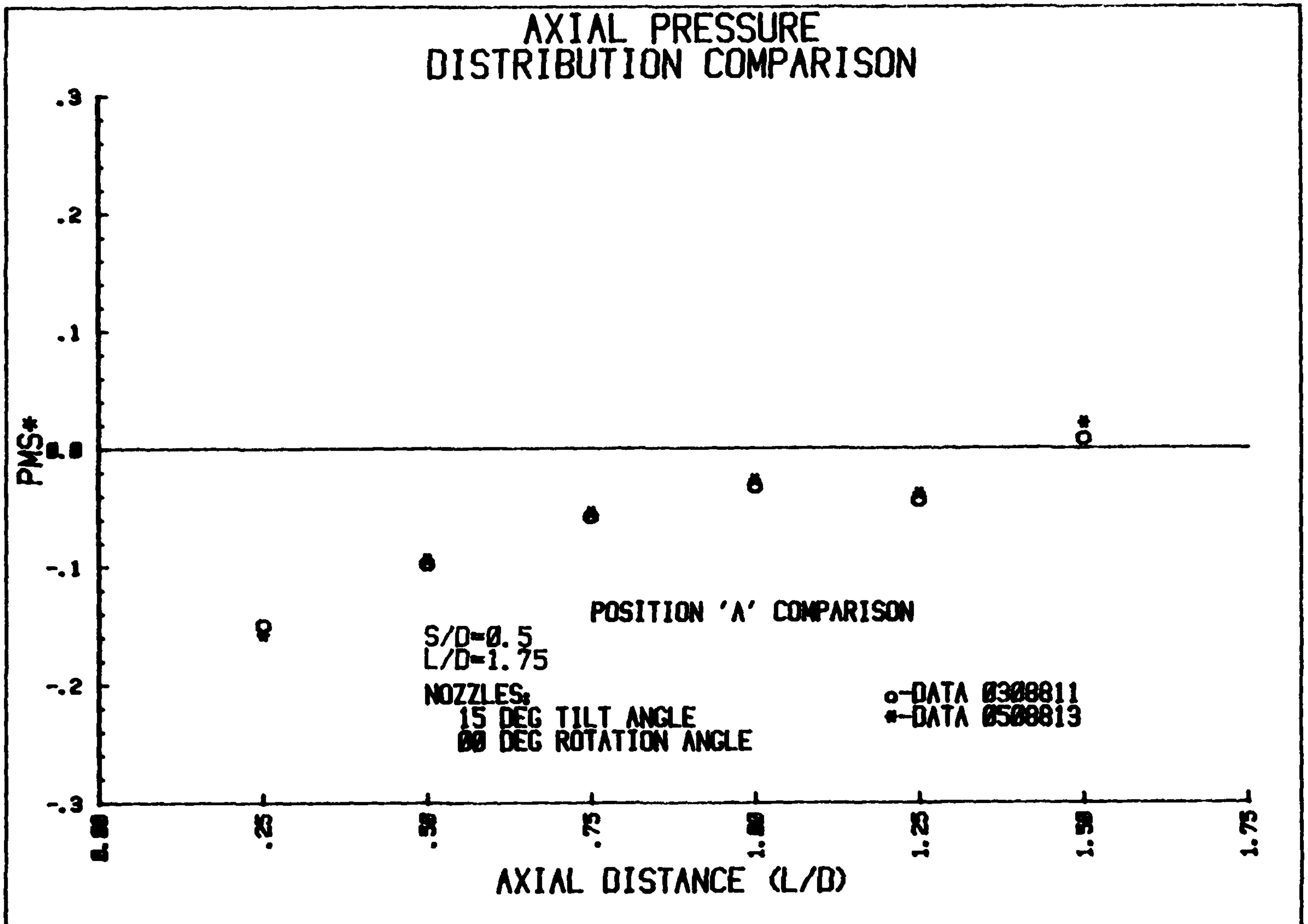

AXIAL PRESSURE
DISTRIBUTION COMPARISON
.3
.2
.1
0.0
-.1
-.2
-.3
PMS*
POSITION 'A' COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
o-DATA 0308811
*-DATA 0508813
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 33.1

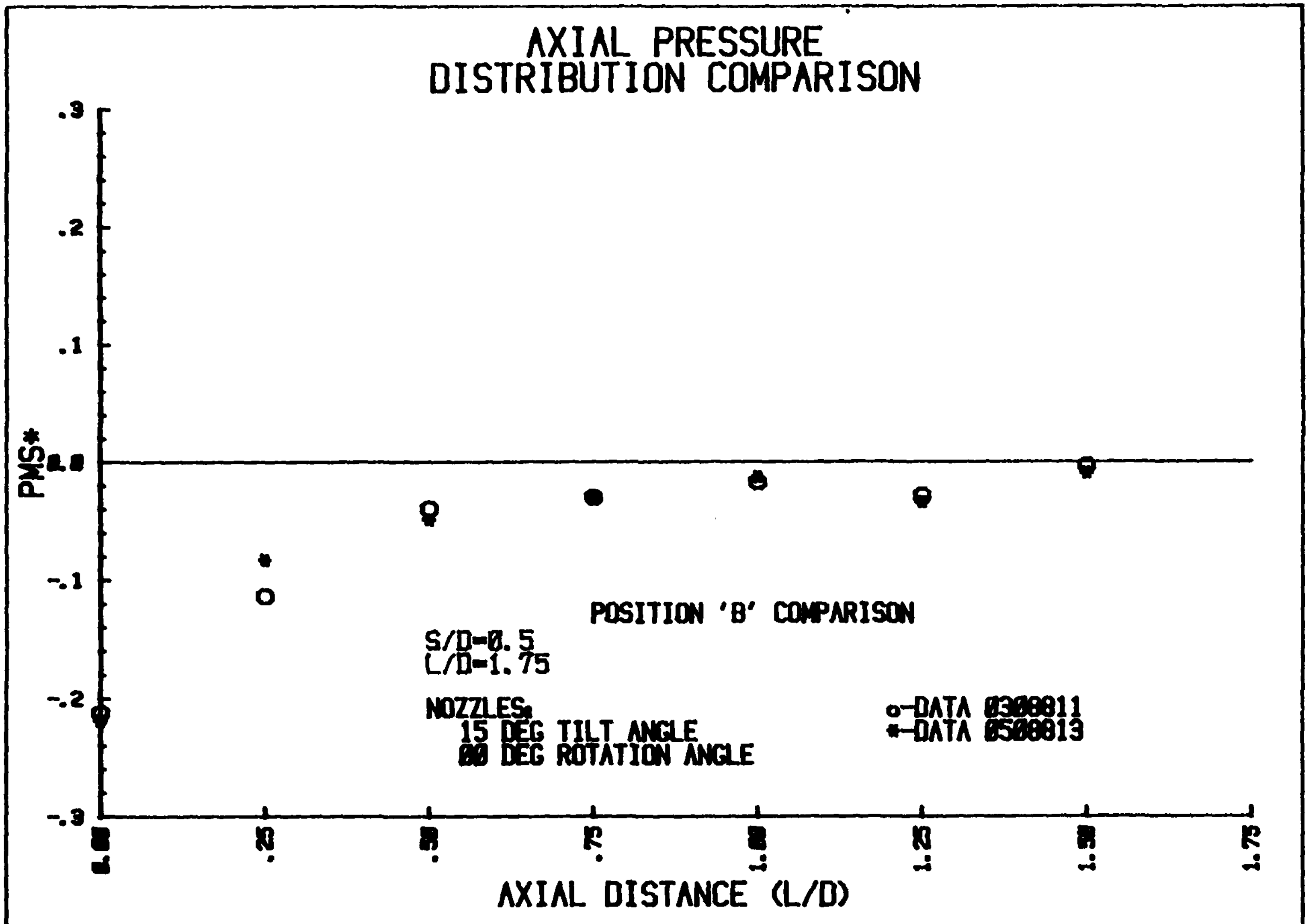

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
POSITION 'B' COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
o-DATA 0300811
*-DATA 0500813
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 33.2

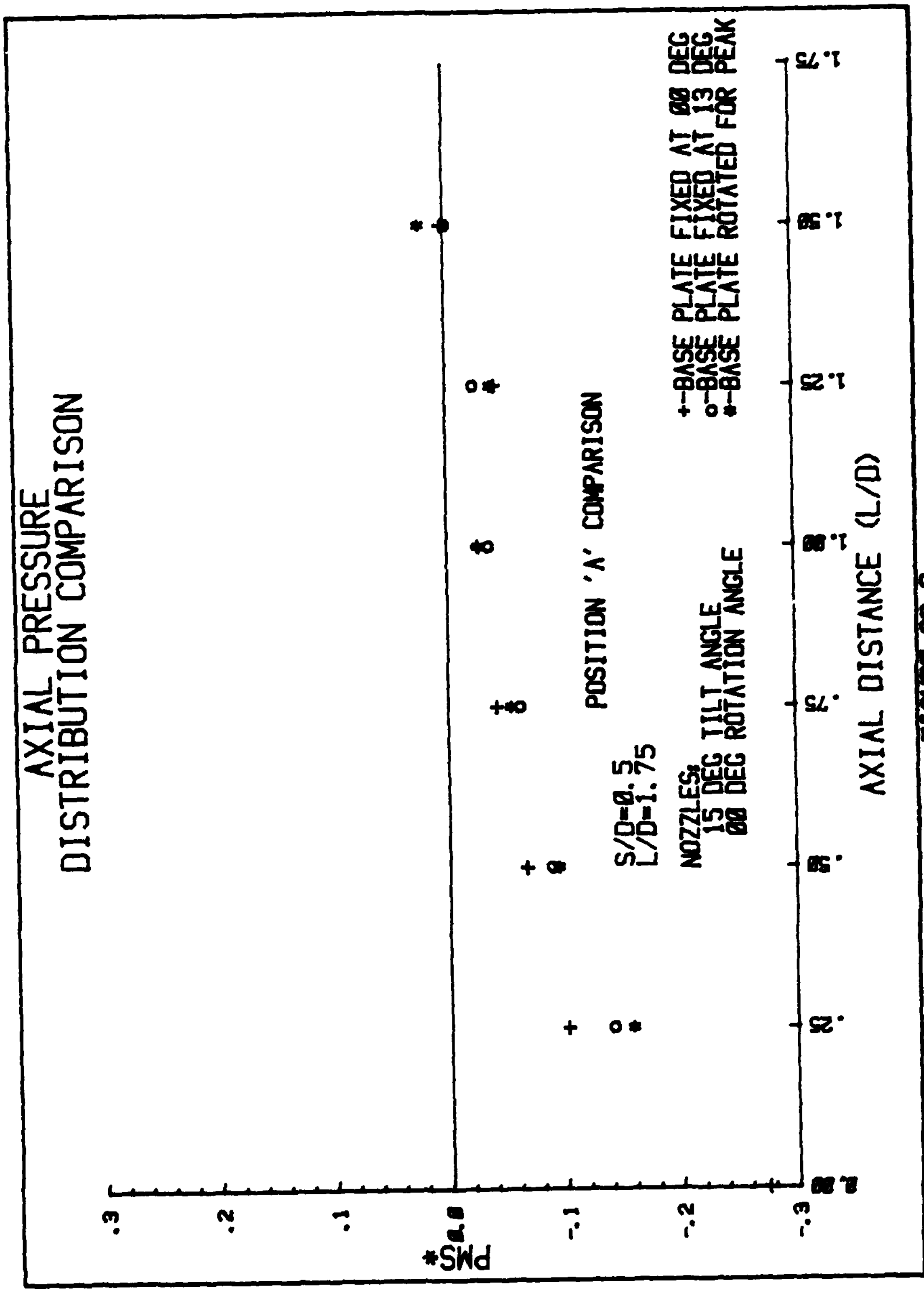

AXIAL PRESSURE
DISTRIBUTION COMPARISON
POSITION 'A' COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
+-BASE PLATE FIXED AT 00 DEG
o-BASE PLATE FIXED AT 13 DEG
*-BASE PLATE ROTATED FOR PEAK
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 33.3

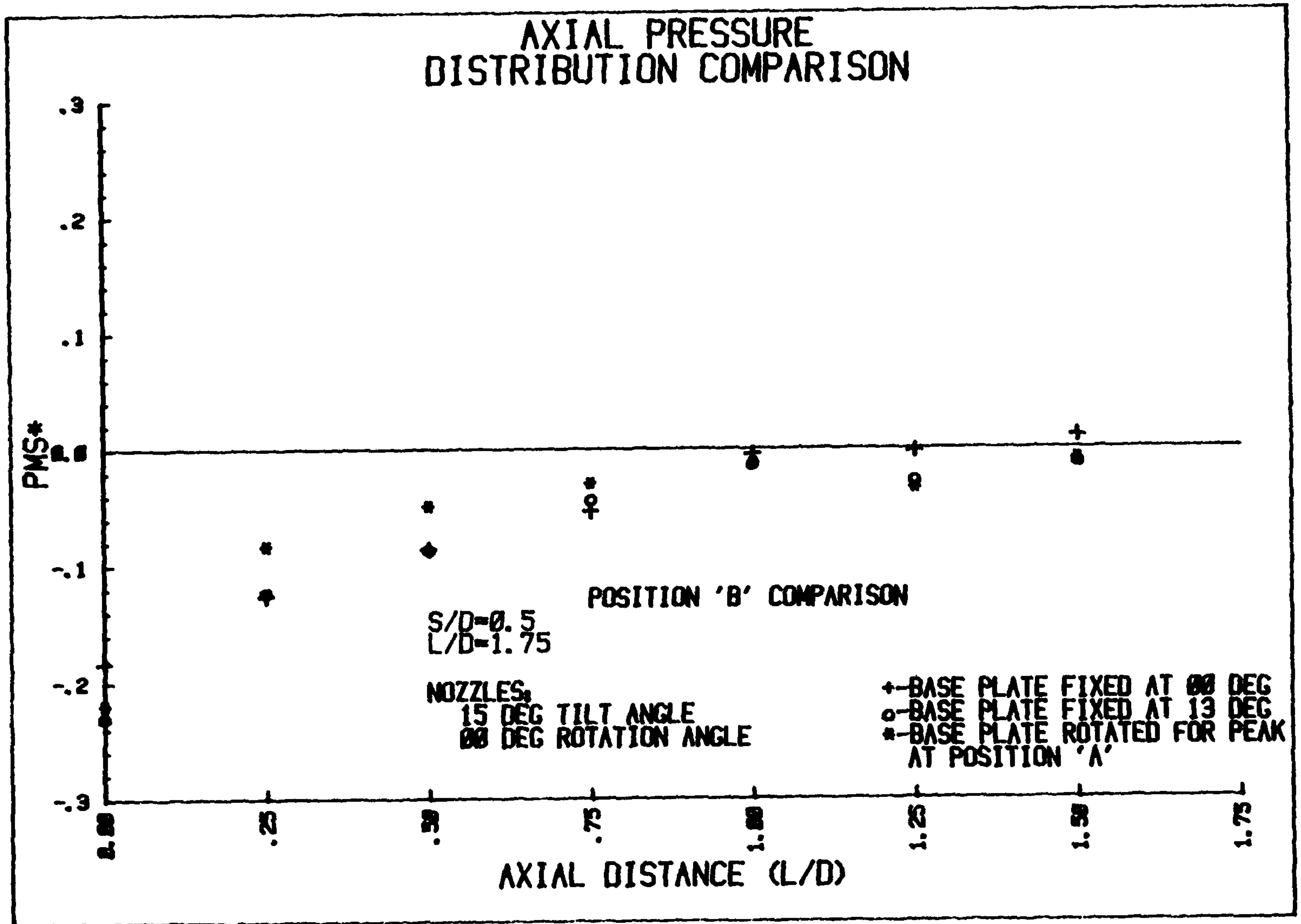

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
POSITION 'B' COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
+-BASE PLATE FIXED AT 00 DEG
o-BASE PLATE FIXED AT 13 DEG
*-BASE PLATE ROTATED FOR PEAK
AT POSITION 'A'

FIGURE 33.4

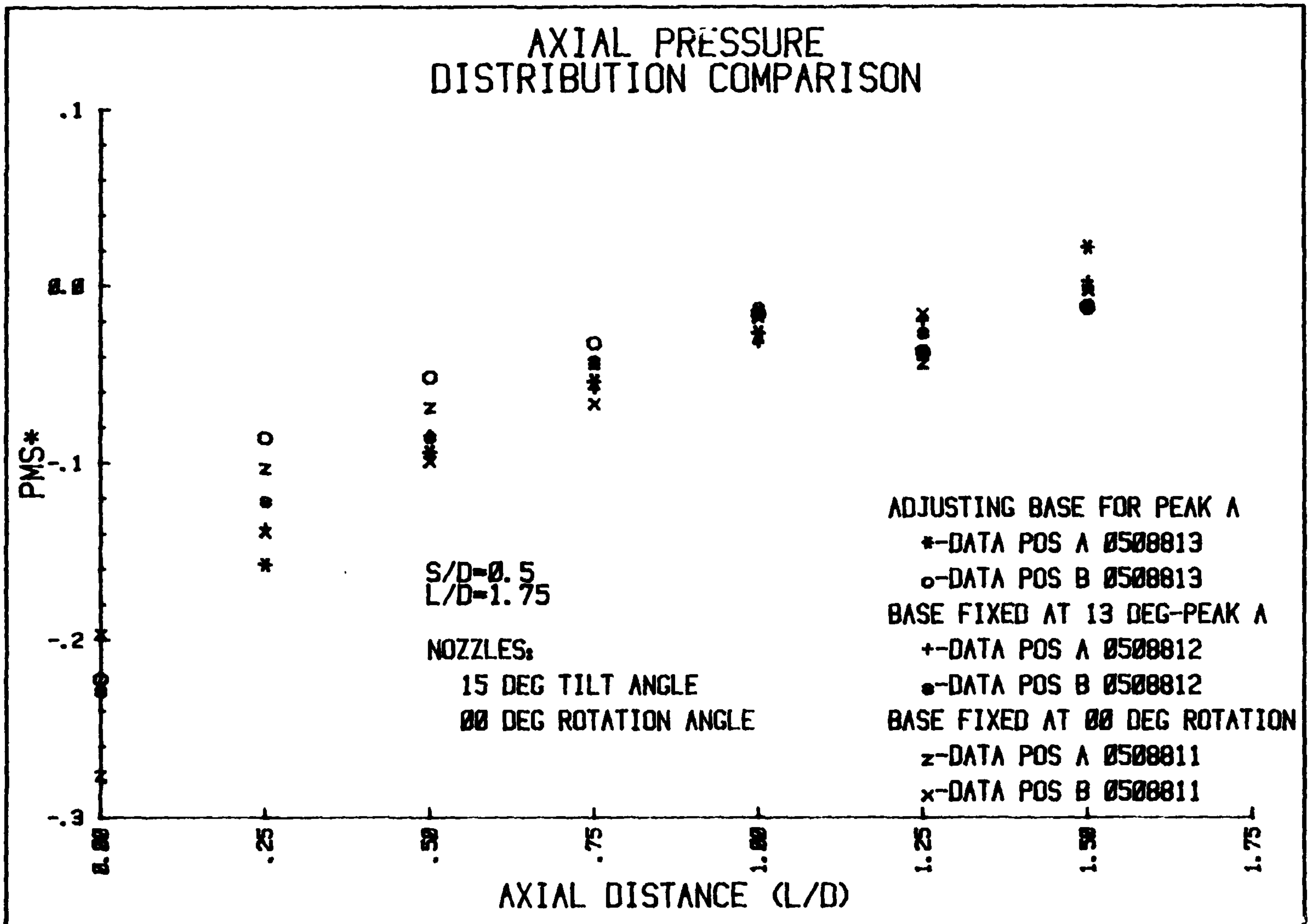

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
00 DEG ROTATION ANGLE
ADJUSTING BASE FOR PEAK A
*-DATA POS A 0508813
o-DATA POS B 0508813
BASE FIXED AT 13 DEG-PEAK A
+-DATA POS A 0508812
●-DATA POS B 0508812
BASE FIXED AT 00 DEG ROTATION
z-DATA POS A 0508811
x-DATA POS B 0508811

FIGURE 33.5

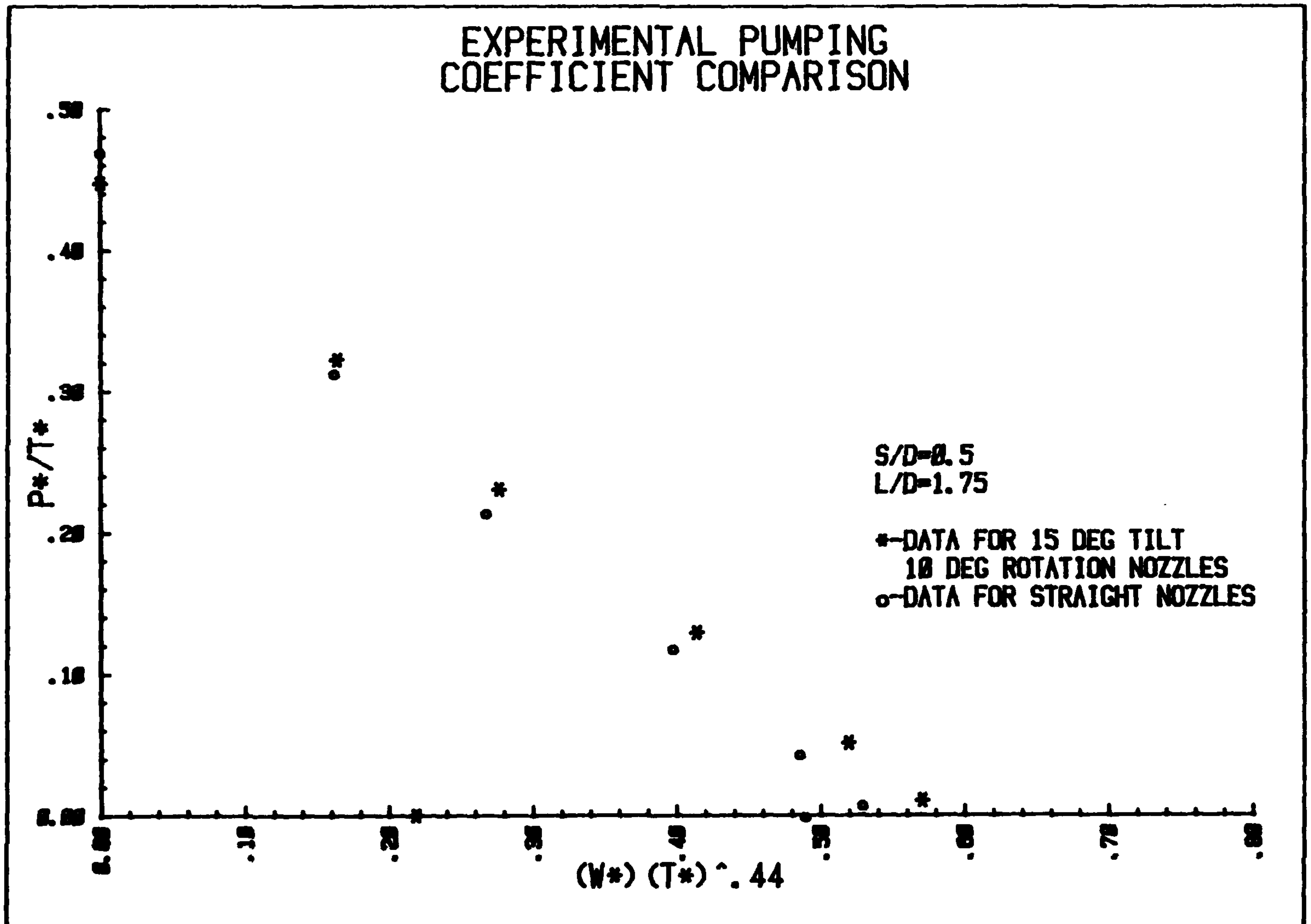

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 34

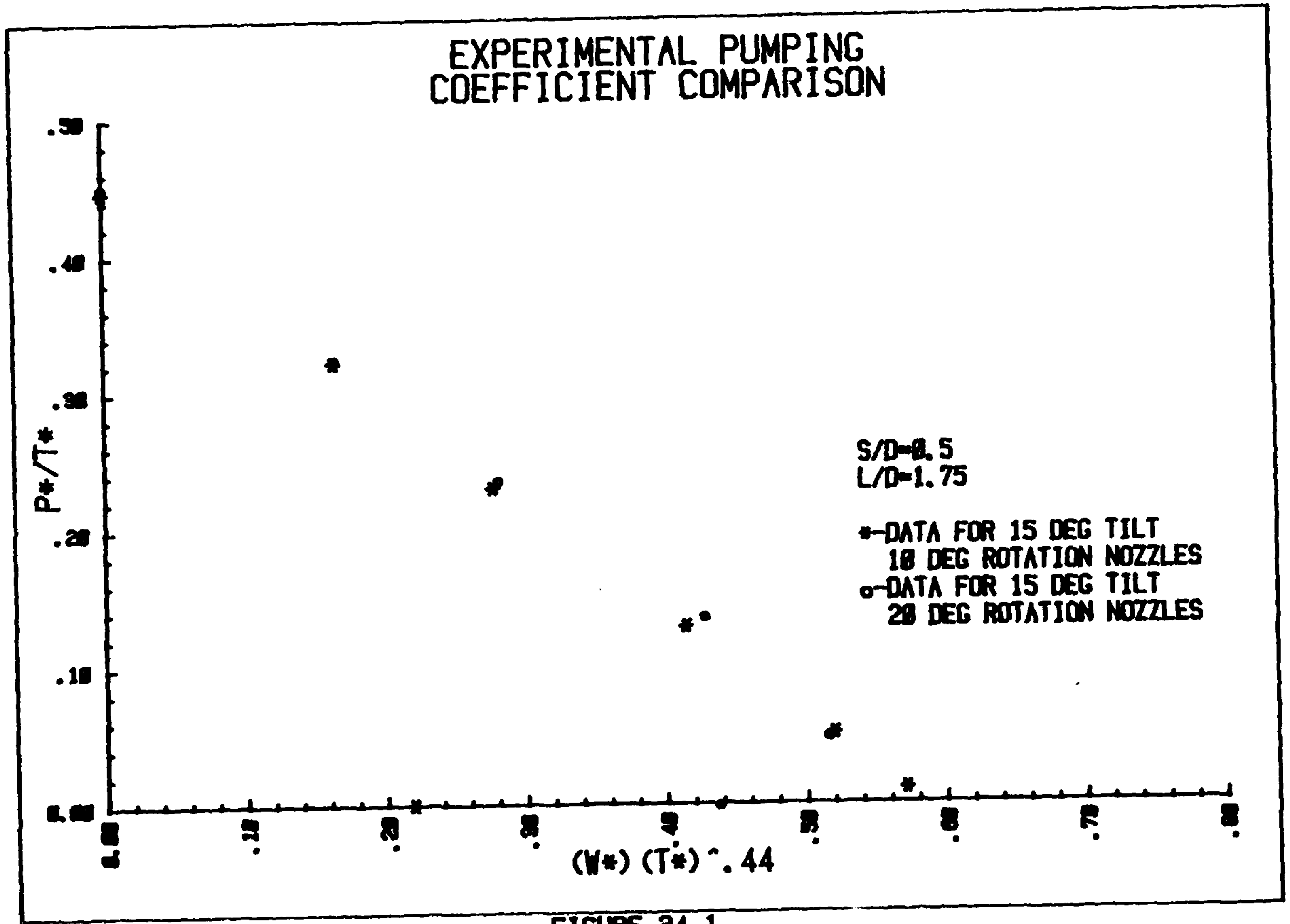

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44

FIGURE 34.1

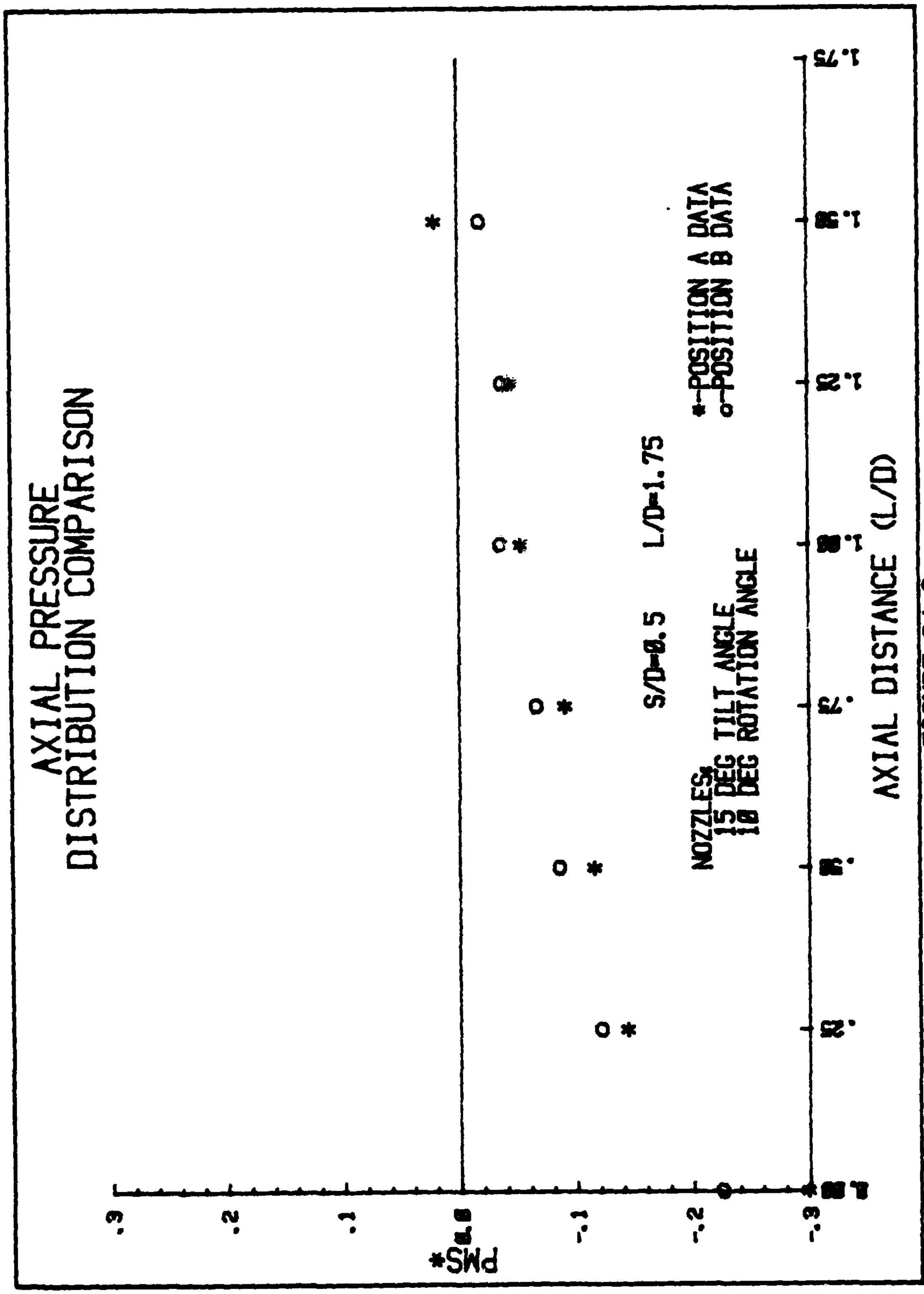

AXIAL PRESSURE
DISTRIBUTION COMPARISON
S/D=0.5 L/D=1.75
NOZZLES
15 DEG TILT ANGLE
10 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
PMS*
AXIAL DISTANCE (L/D)
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75

FIGURE 34.2

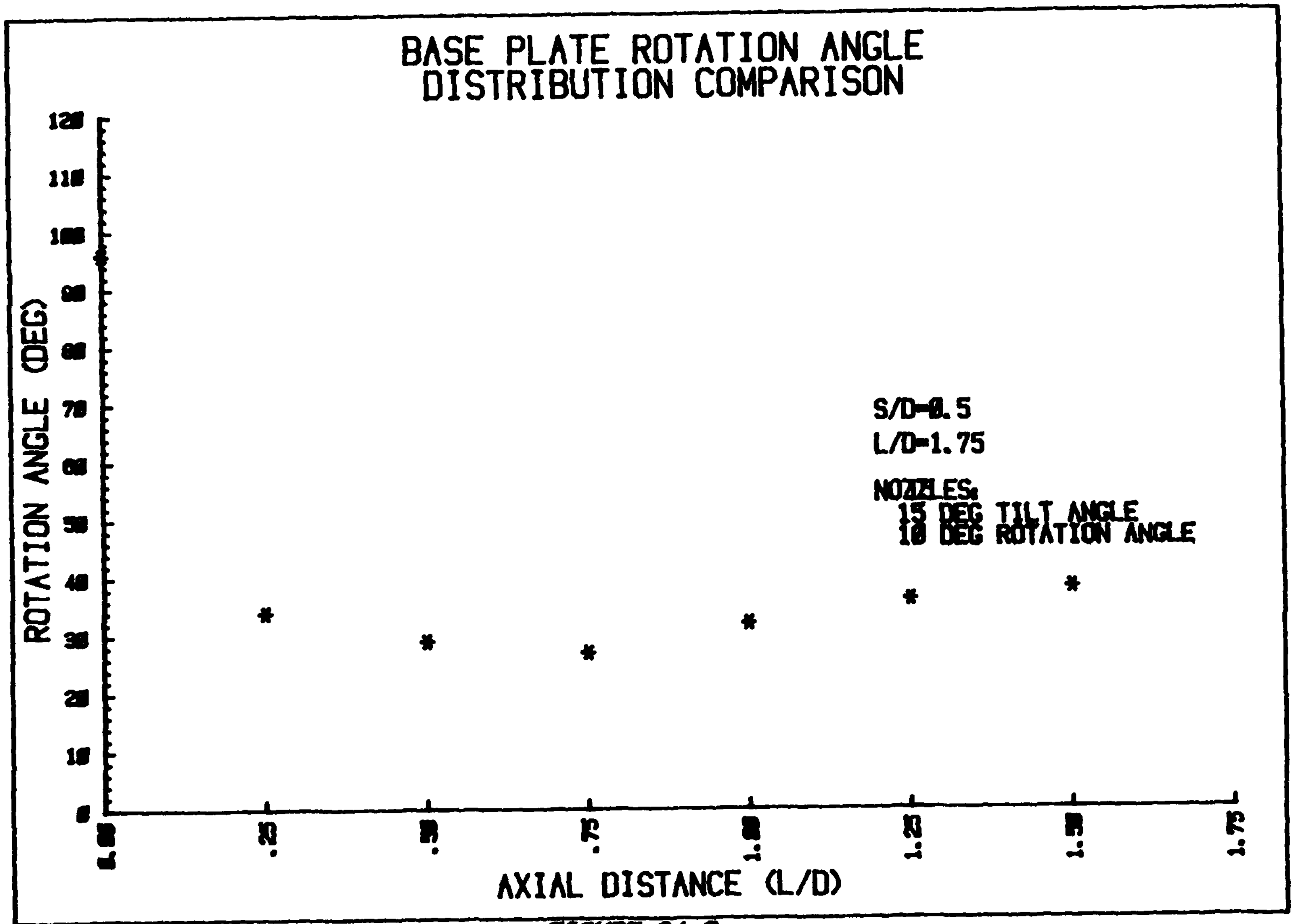
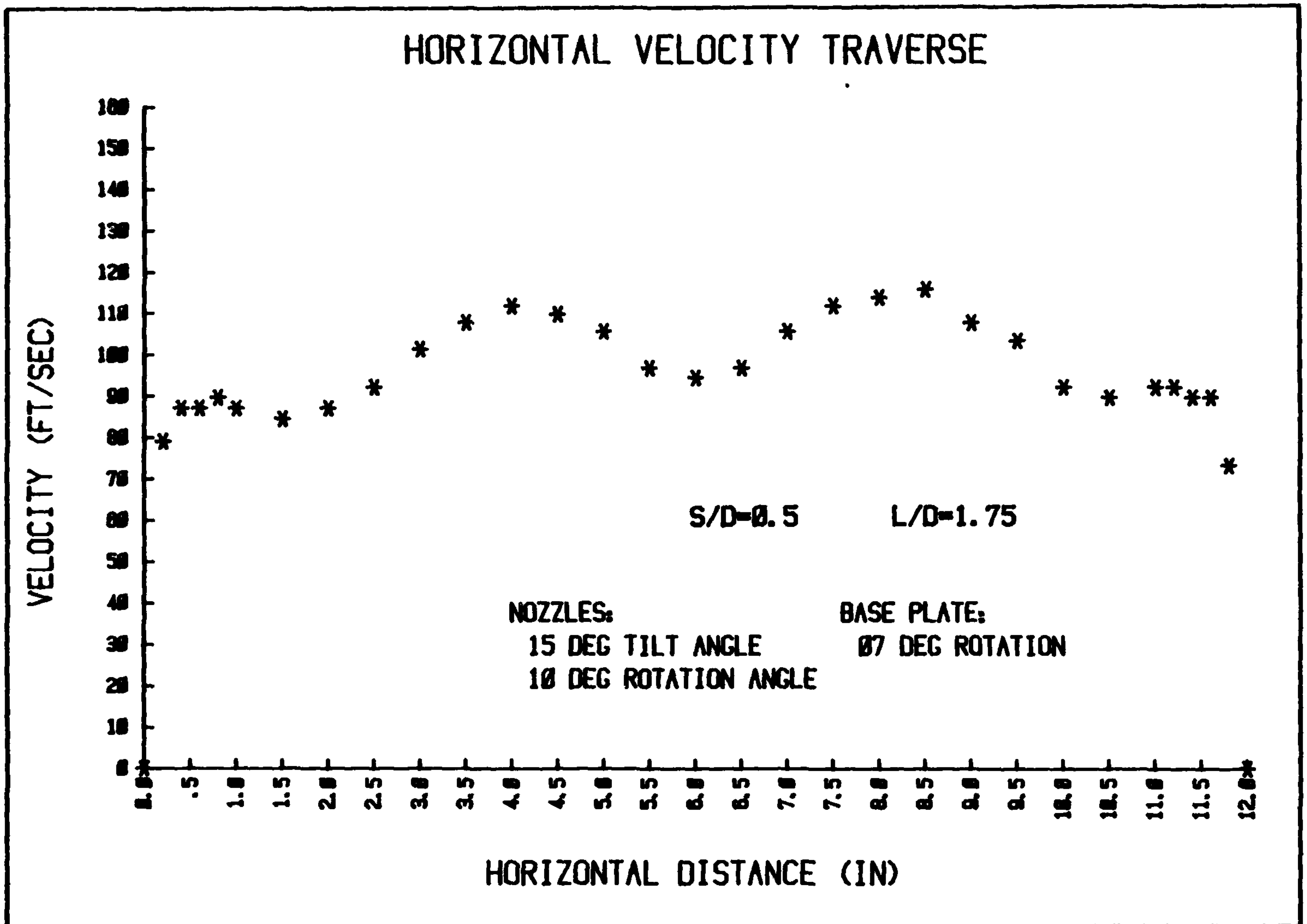

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
10 DEG ROTATION ANGLE
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 34.3


HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
10 DEG ROTATION ANGLE
BASE PLATE:
07 DEG ROTATION
FIGURE 34.4

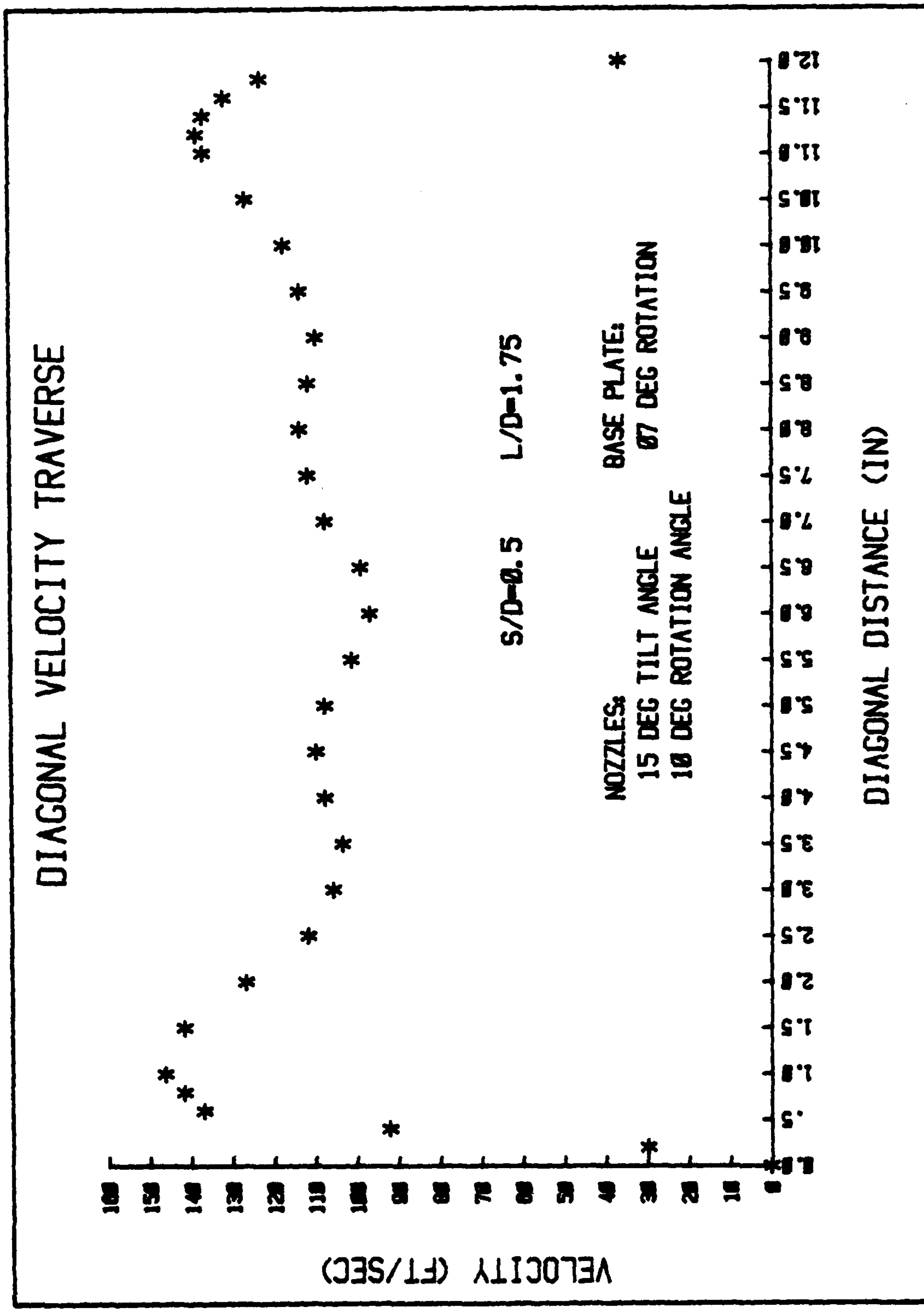

DIAGONAL VELOCITY TRAVERSE
S/D=0.5 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
10 DEG ROTATION ANGLE
BASE PLATE:
07 DEG ROTATION
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)
0.0 .5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0

FIGURE 34.5

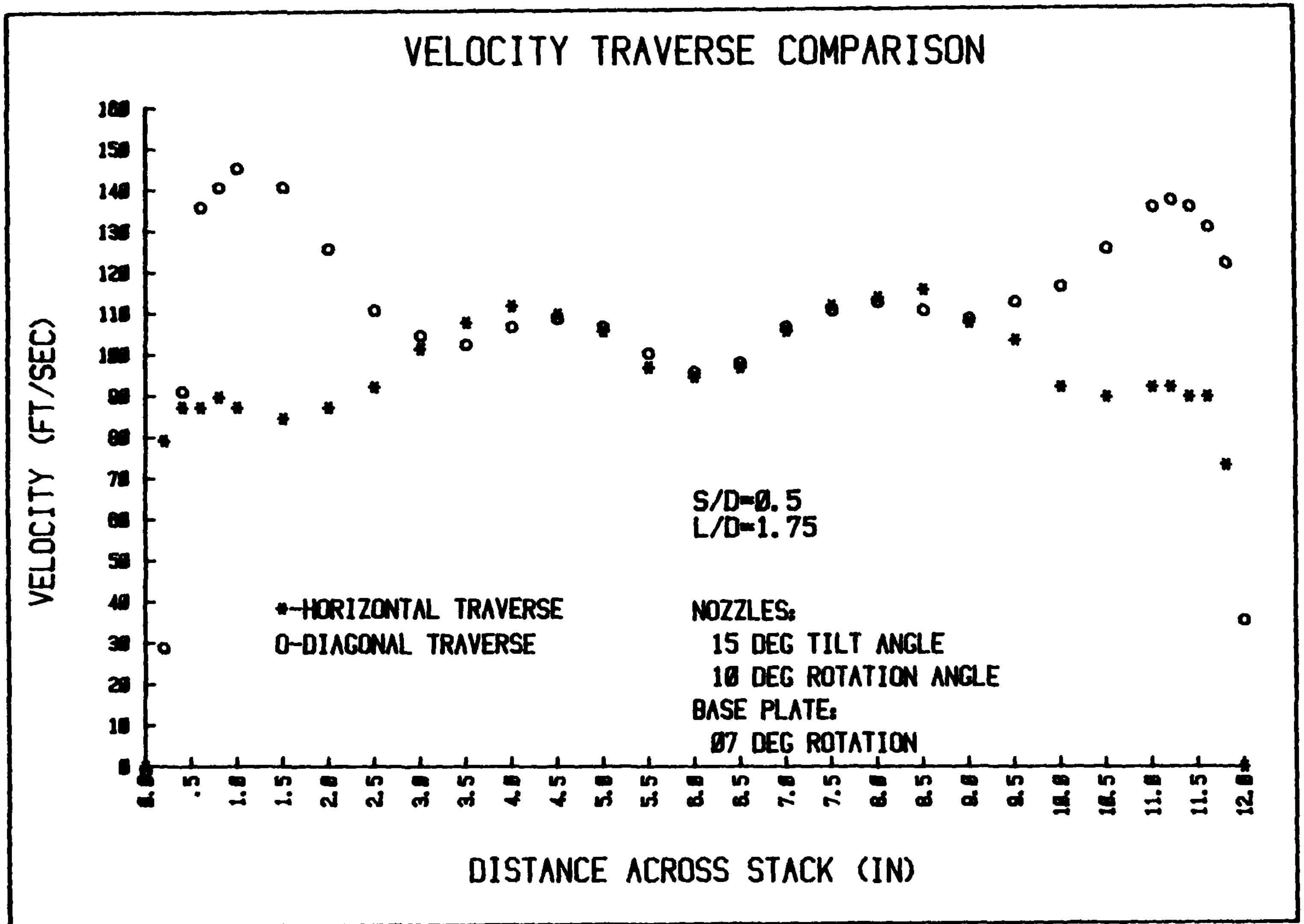
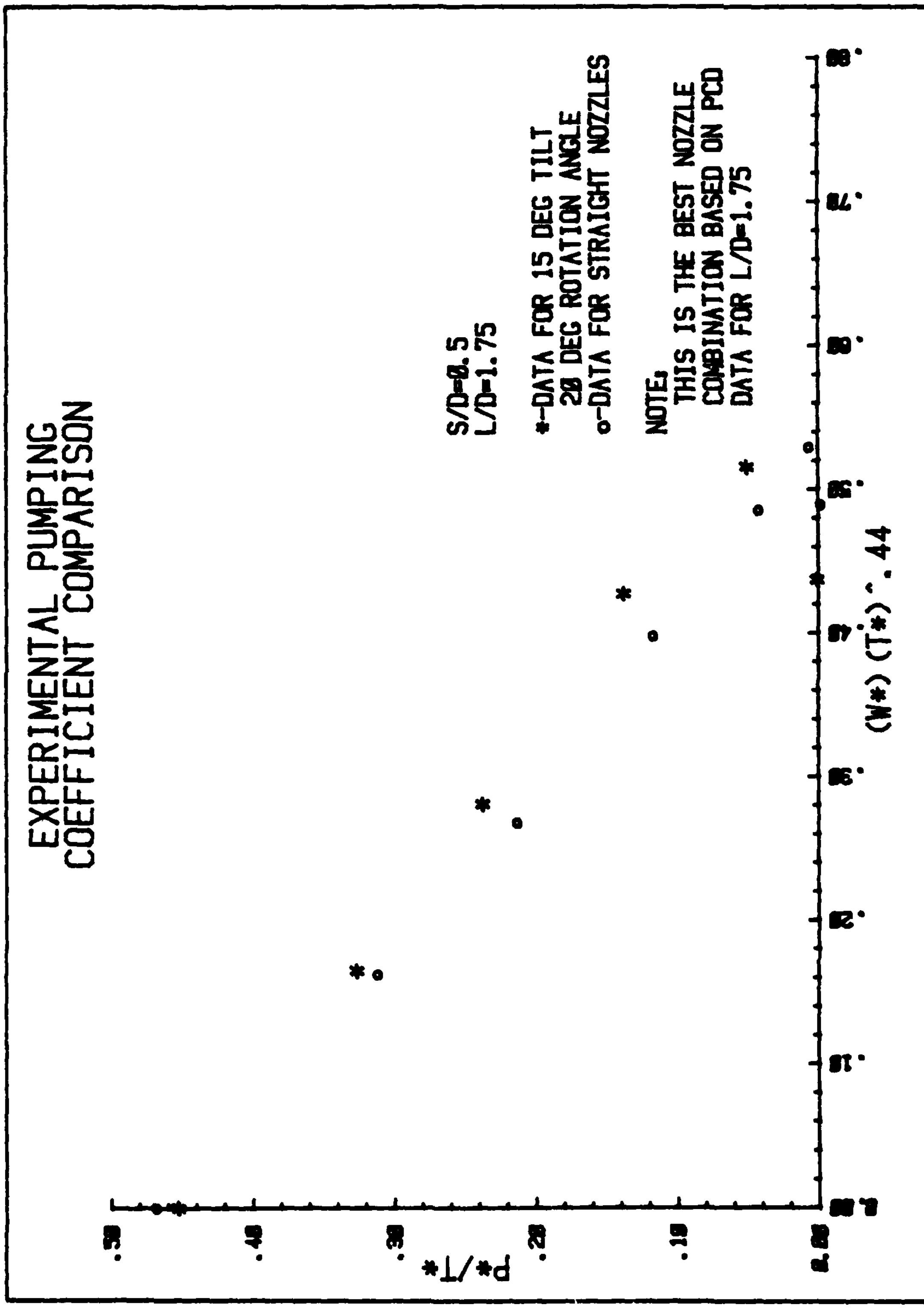

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
S/D=Ø.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
1Ø DEG ROTATION ANGLE
BASE PLATE:
Ø7 DEG ROTATION

FIGURE 34.6



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
20 DEG ROTATION ANGLE
o-DATA FOR STRAIGHT NOZZLES
NOTE:
THIS IS THE BEST NOZZLE
COMBINATION BASED ON PCD
DATA FOR L/D=1.75
P*/T*
(W*)(T*)^.44

FIGURE 35

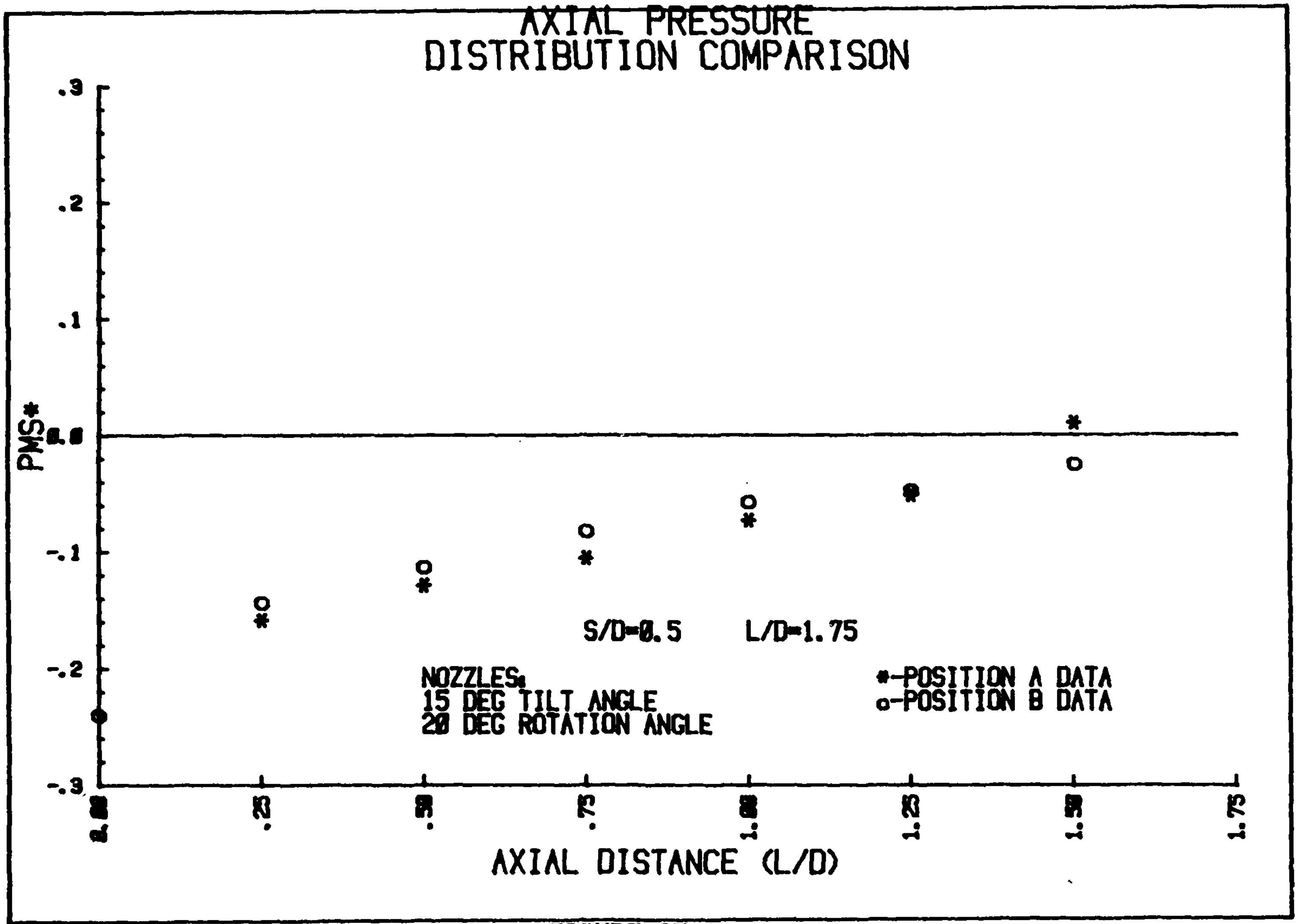

AXIAL PRESSURE
DISTRIBUTION COMPARISON
.3
.2
.1
0.0
-.1
-.2
-.3
PMS*
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 35.1

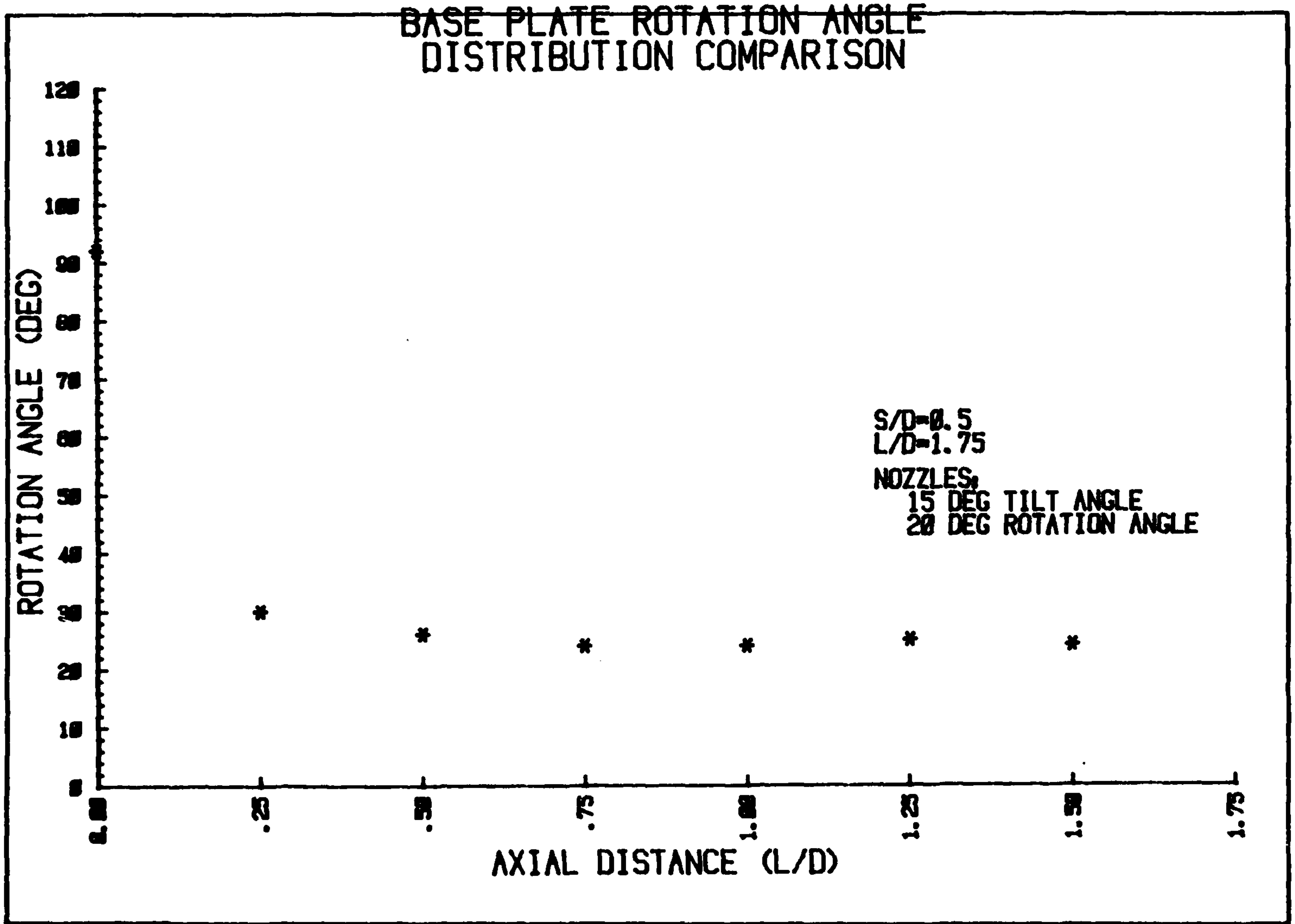

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
ROTATION ANGLE (DEG)
AXIAL DISTANCE (L/D)

FIGURE 35.2

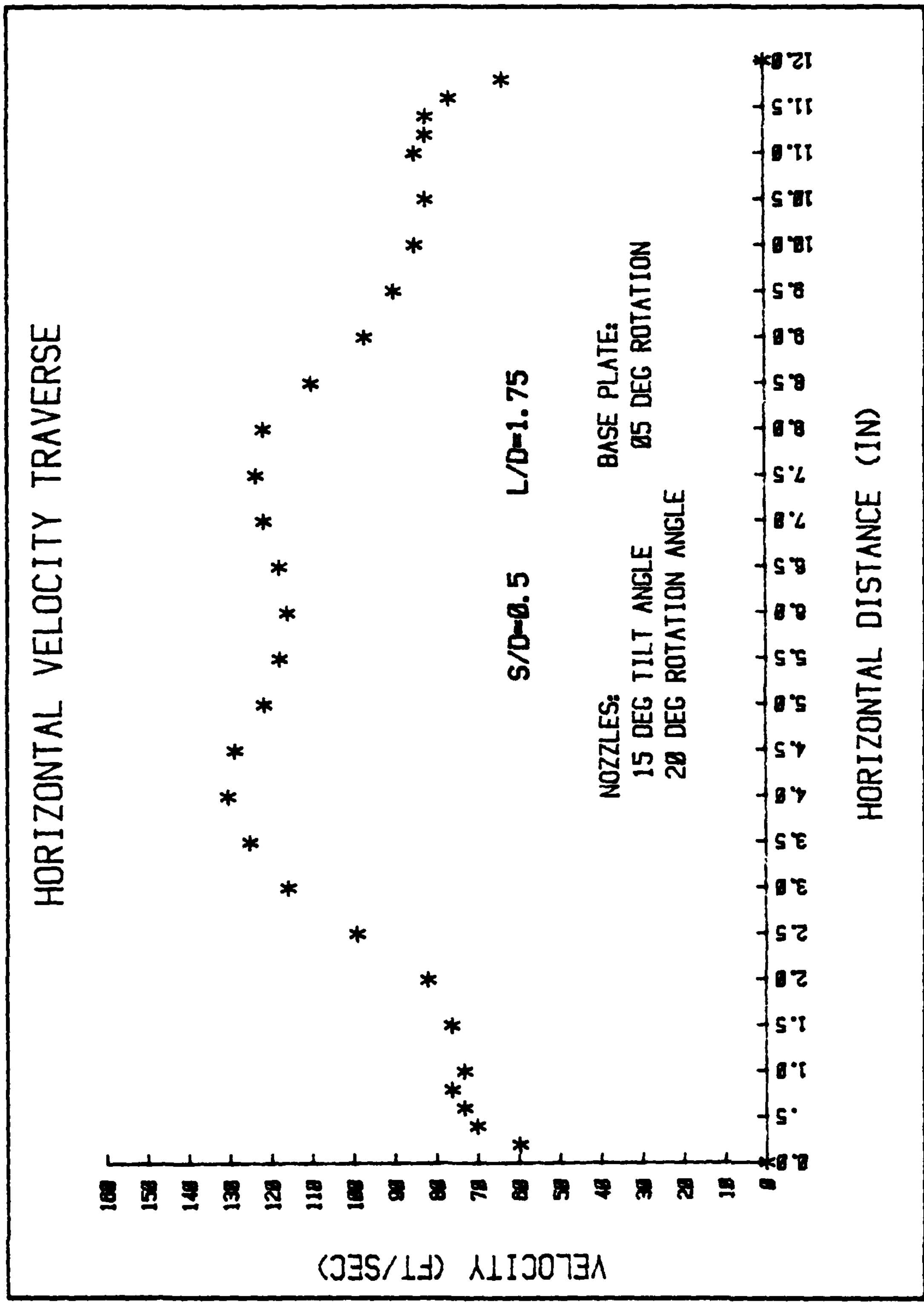
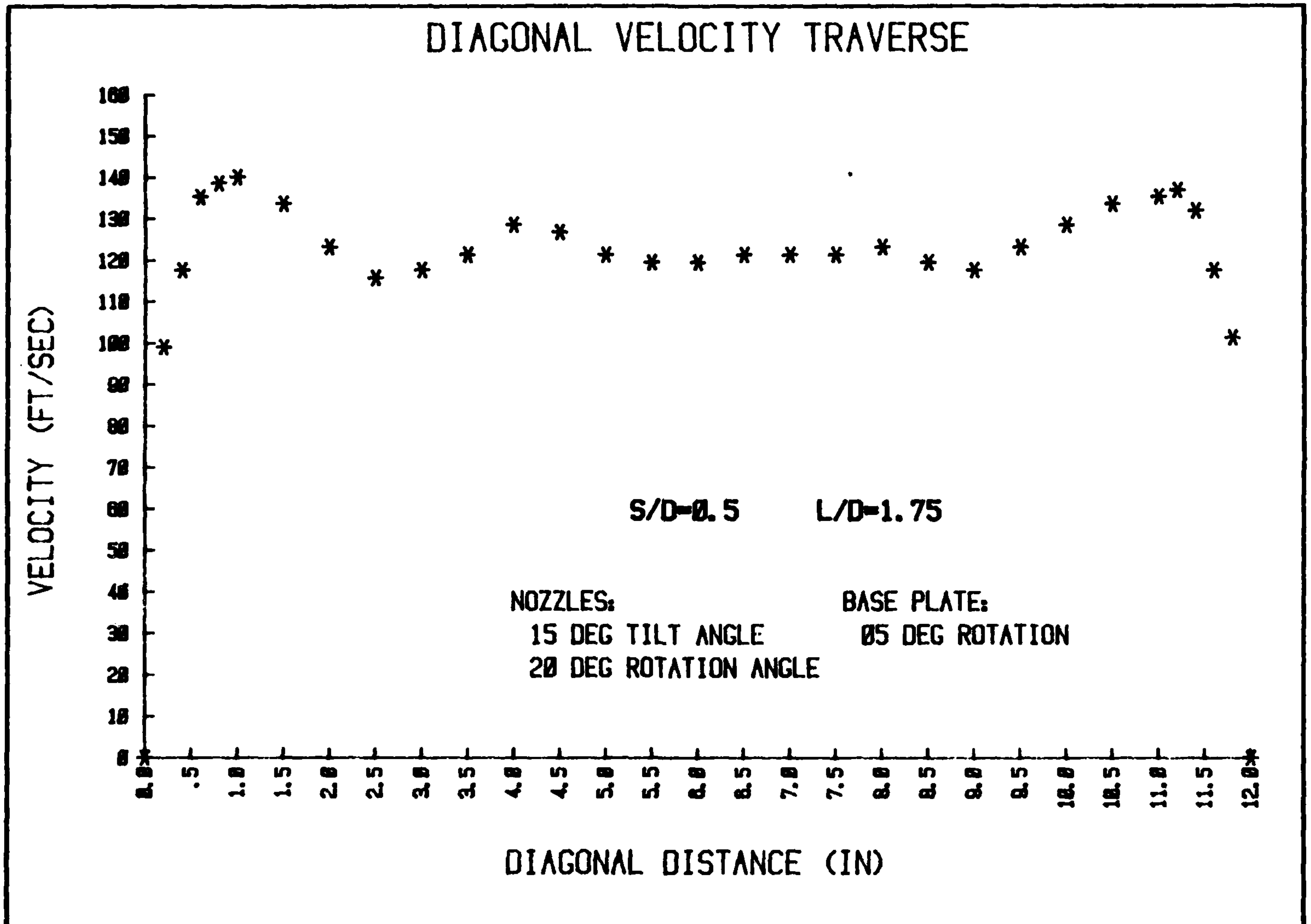

HORIZONTAL VELOCITY TRAVERSE
S/D=0.5 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
05 DEG ROTATION
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0

FIGURE 35.3



DIAGONAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)
S/D=0.5 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
05 DEG ROTATION

FIGURE 35.4

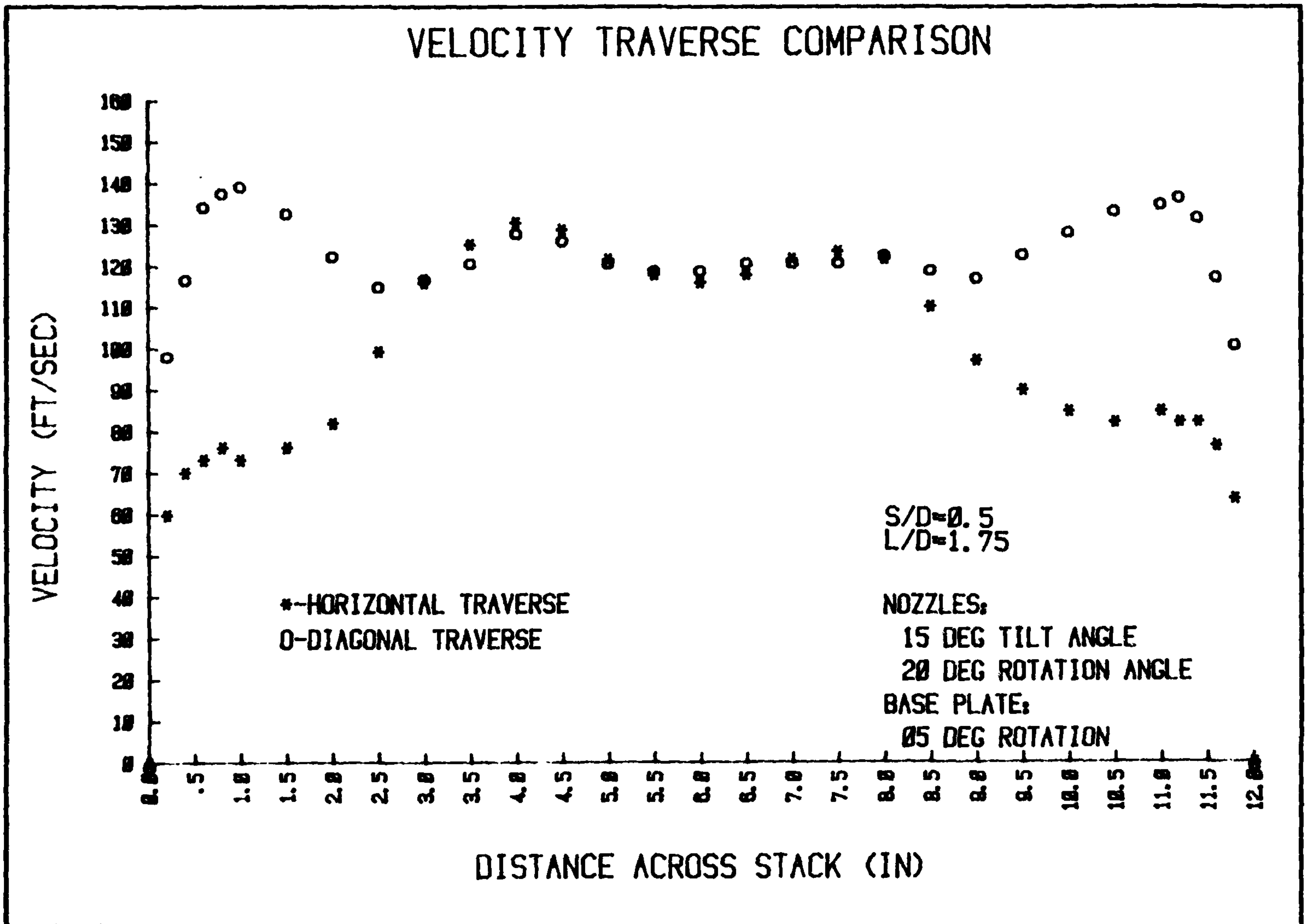

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
S/D=Ø.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
2Ø DEG ROTATION ANGLE
BASE PLATE:
Ø5 DEG ROTATION

FIGURE 35.5

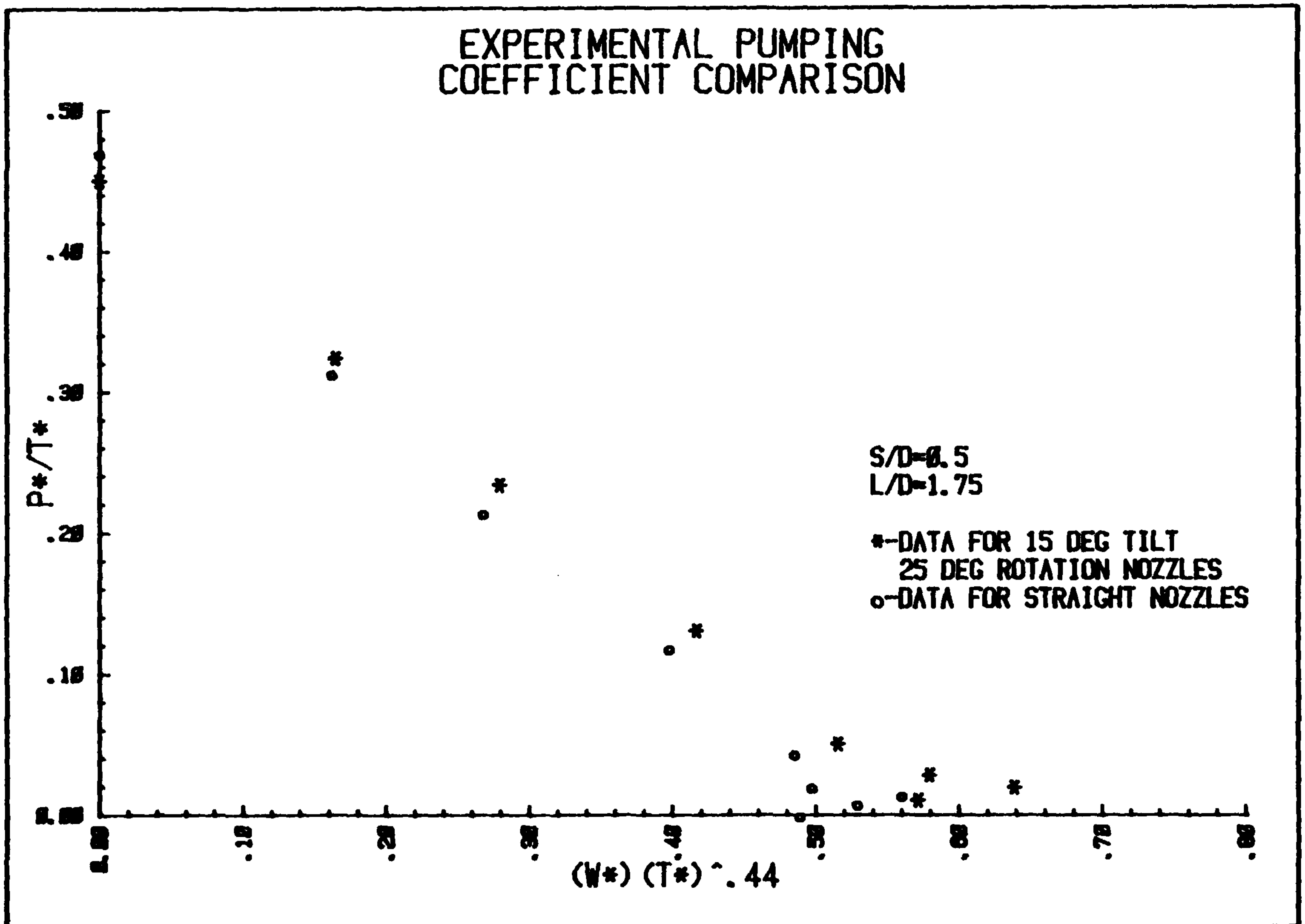
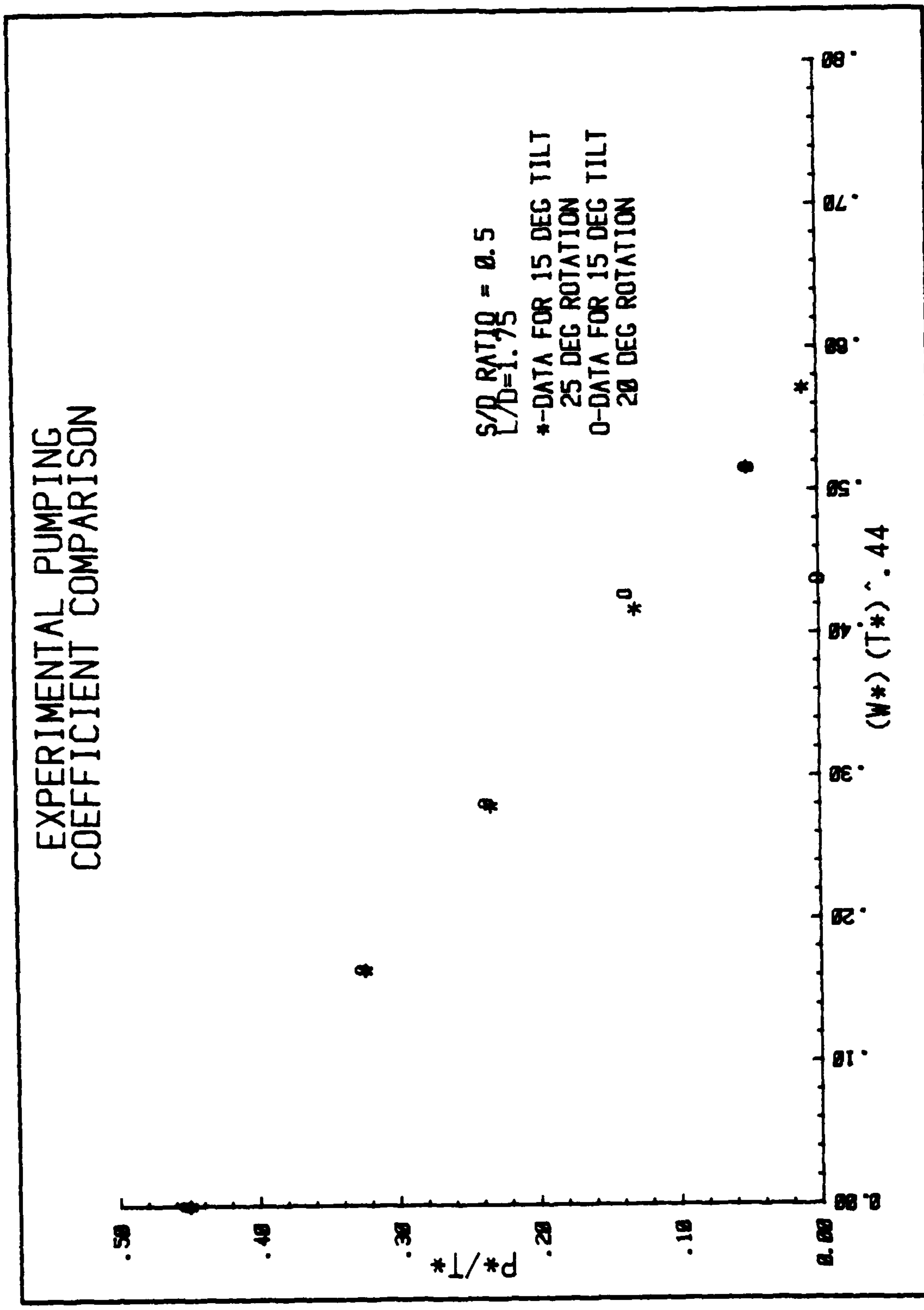
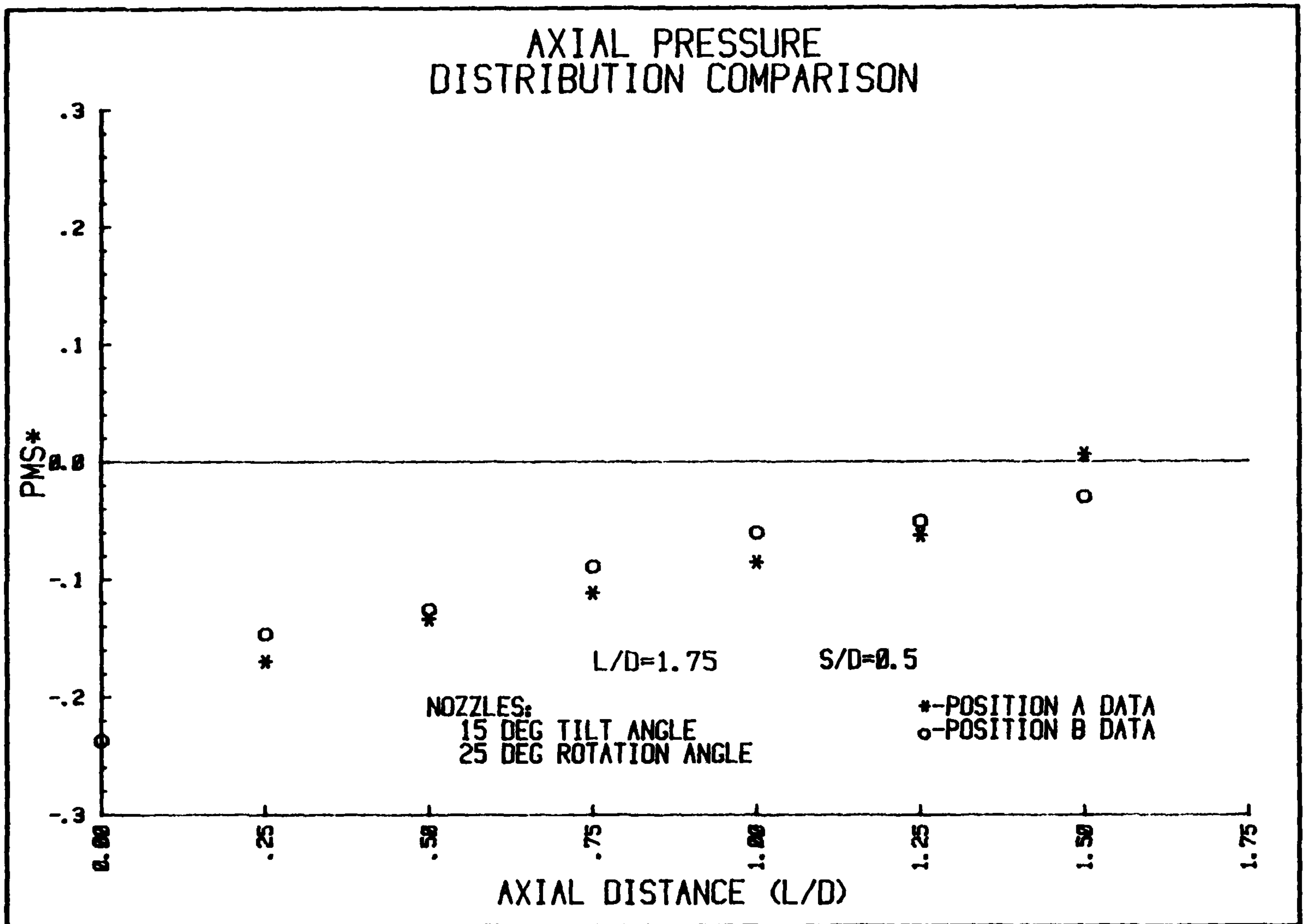

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
.50
.40
.30
.20
.10
0.00
P*/T*
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
25 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 36



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D RATIO = 0.5
L/D=1.75
*--DATA FOR 15 DEG TILT
25 DEG ROTATION
O-DATA FOR 15 DEG TILT
20 DEG ROTATION
P*/T*
0.00
.10
.20
.30
.40
.50
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 30.1



AXIAL PRESSURE
DISTRIBUTION COMPARISON
.3
.2
.1
0.0
-.1
-.2
-.3
PMS*
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 38.2

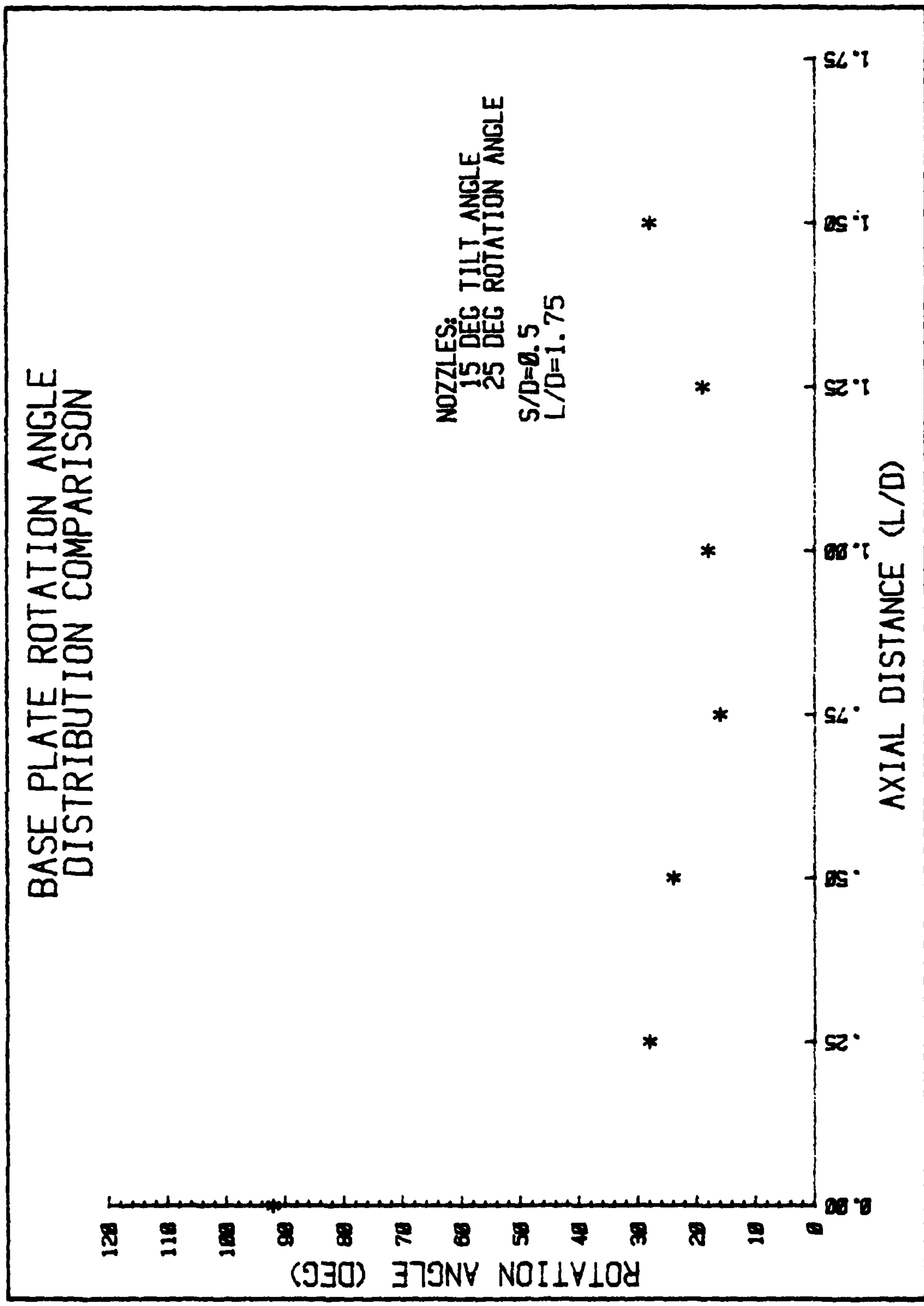

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
S/D=0.5
L/D=1.75
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 38.3

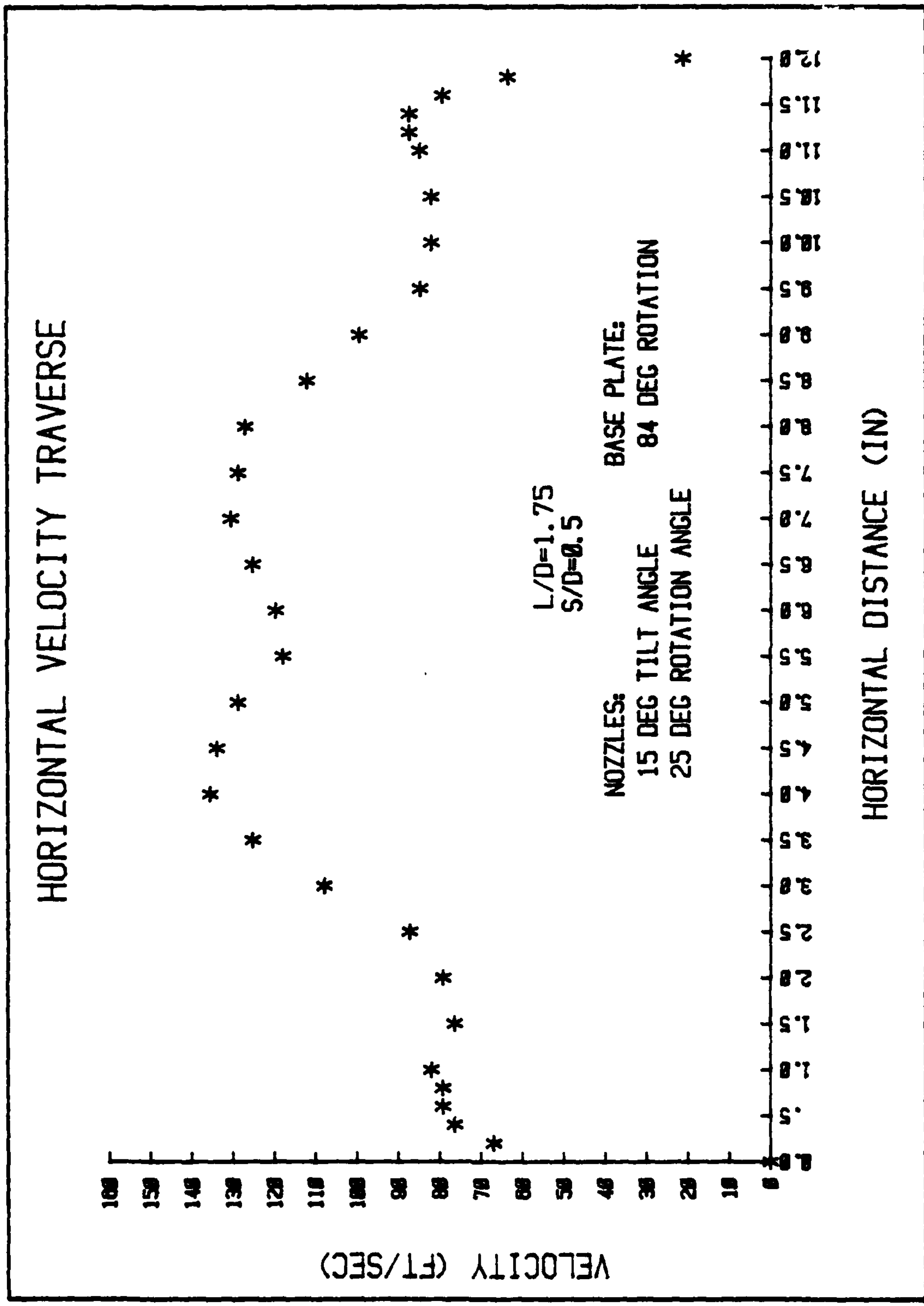

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160
HORIZONTAL DISTANCE (IN)
0.0 .5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
84 DEG ROTATION

FIGURE 38.4

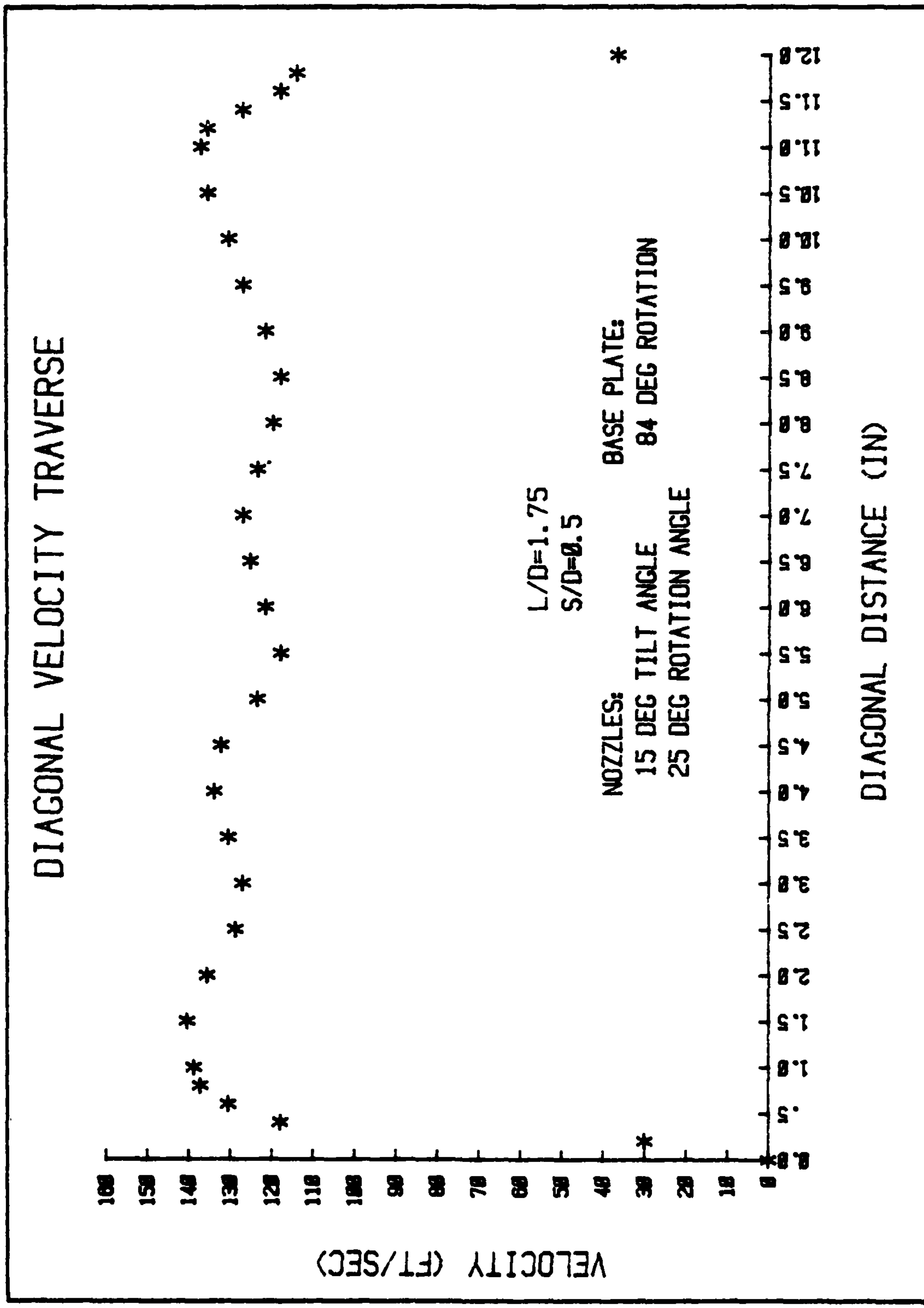

DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
84 DEG ROTATION
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)

FIGURE 38.5

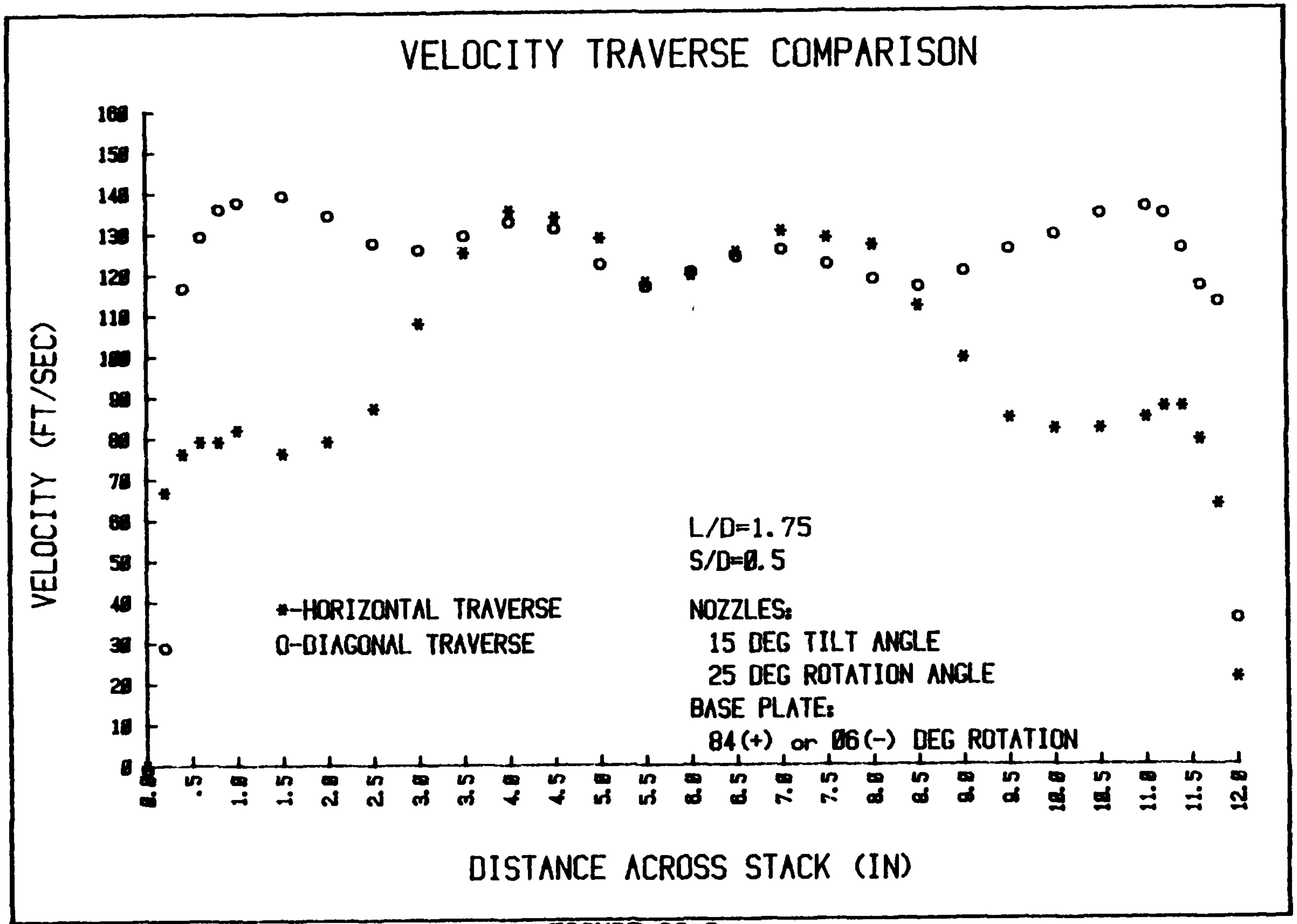

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
84(+) or 06(-) DEG ROTATION

FIGURE 36.6

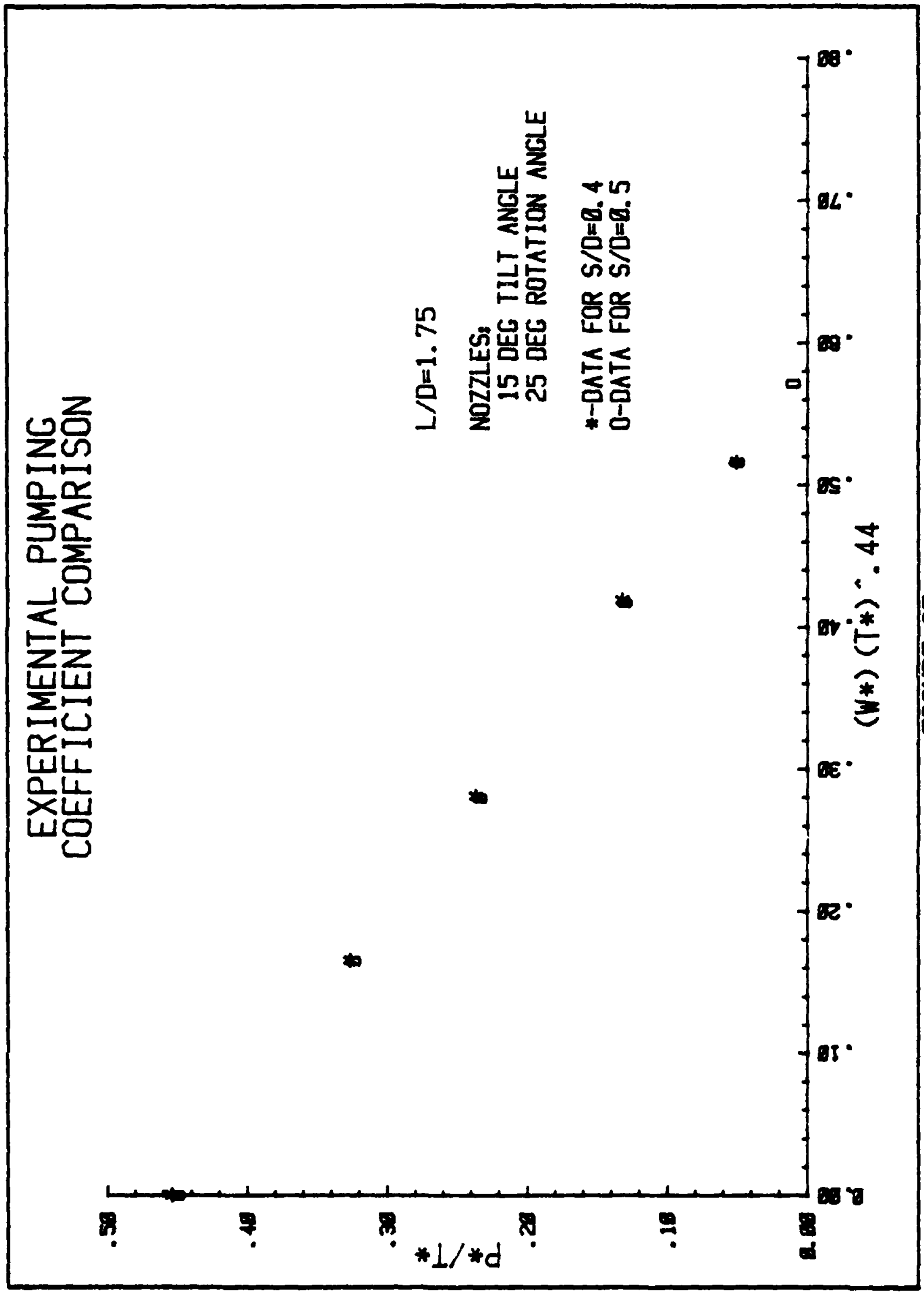

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
*-DATA FOR S/D=0.4
O-DATA FOR S/D=0.5
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 37

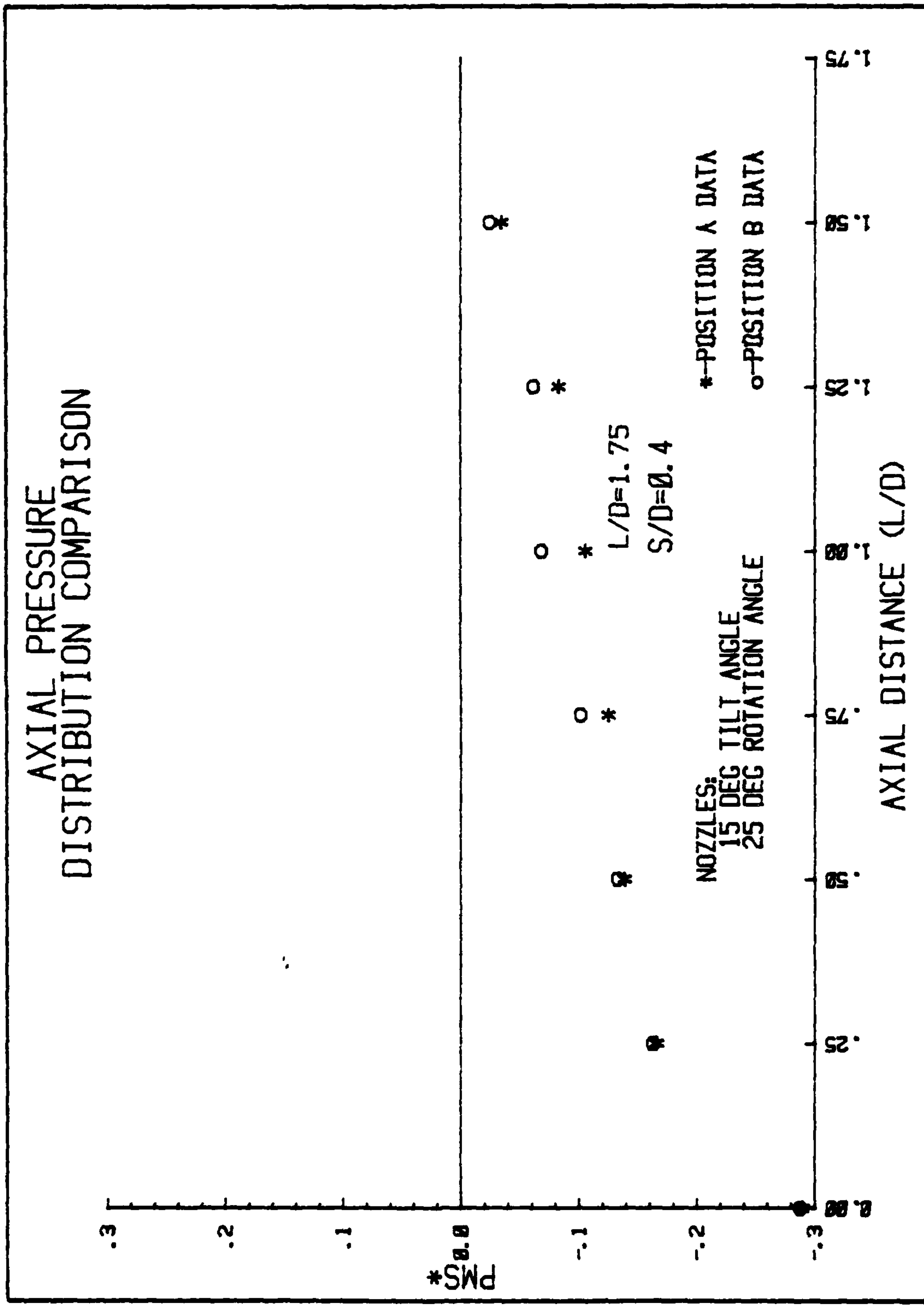

AXIAL PRESSURE
DISTRIBUTION COMPARISON
L/D=1.75
S/D=Ø.4
*-POSITION A DATA
o-POSITION B DATA
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
PMS*
.3
.2
.1
Ø.Ø
-.1
-.2
-.3
Ø.ØØ
.25
.5Ø
.75
1.ØØ
1.25
1.5Ø
1.75
AXIAL DISTANCE (L/D)

FIGURE 37.1

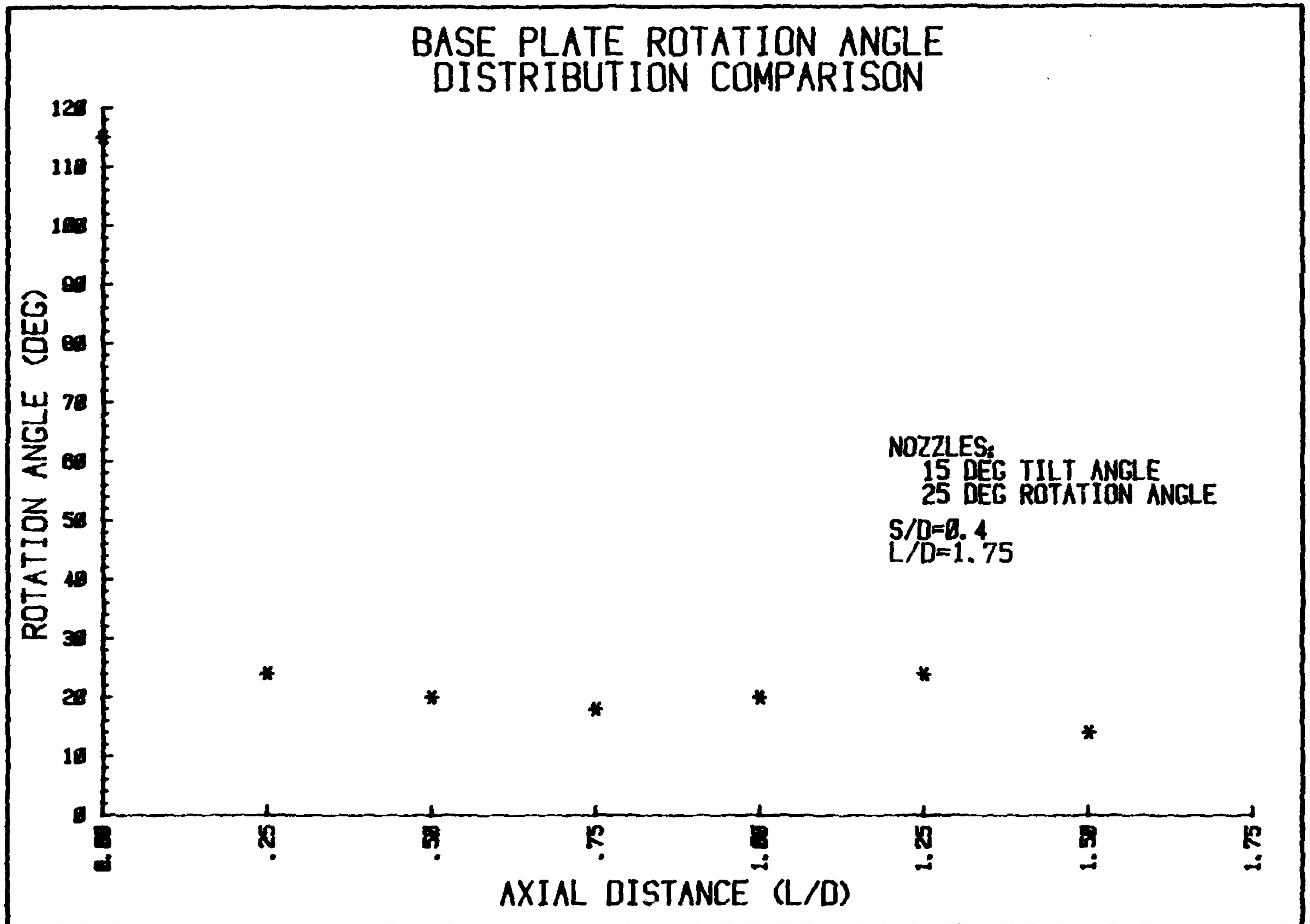

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
AXIAL DISTANCE (L/D)
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
S/D=0.4
L/D=1.75

FIGURE 37.2

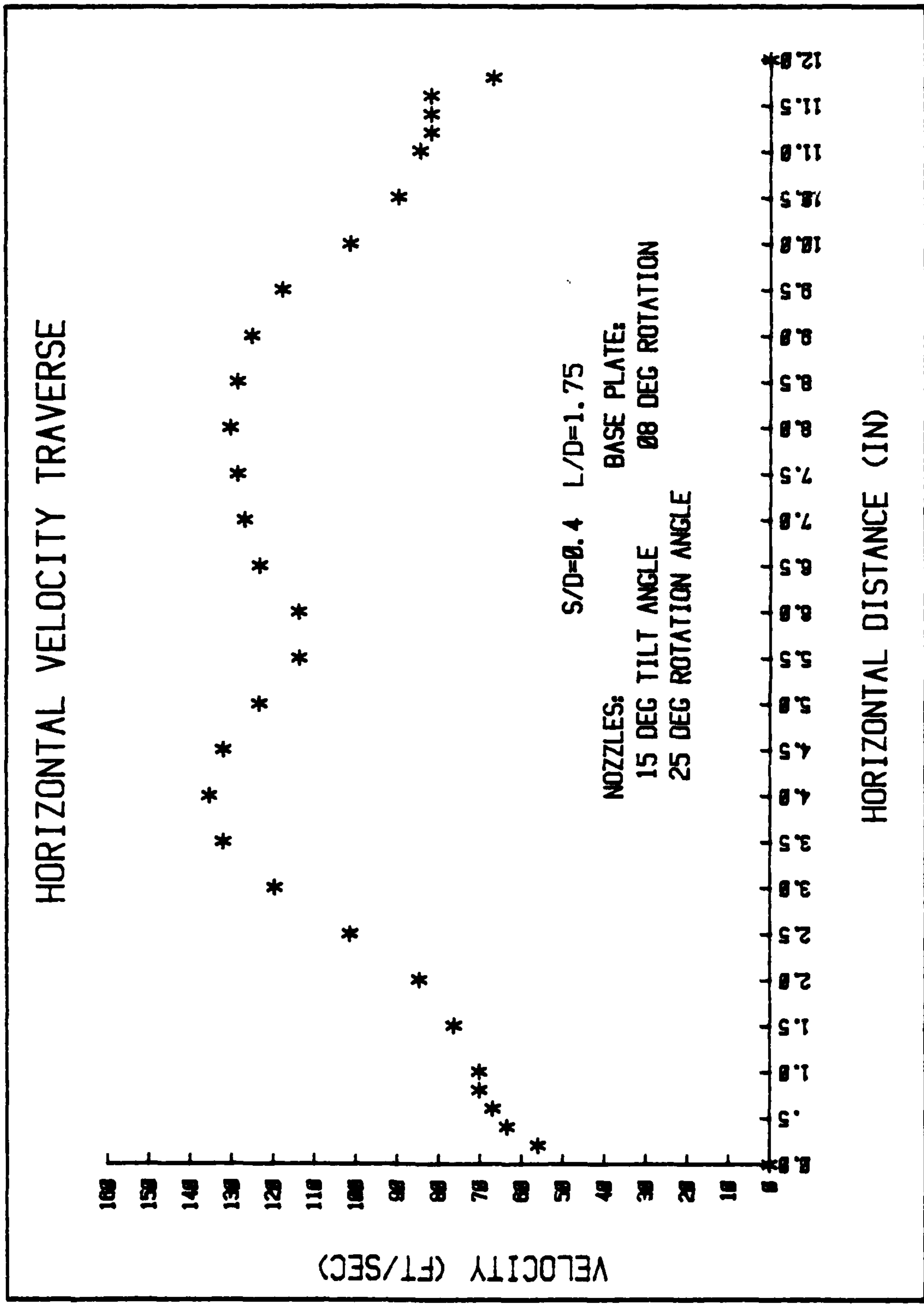
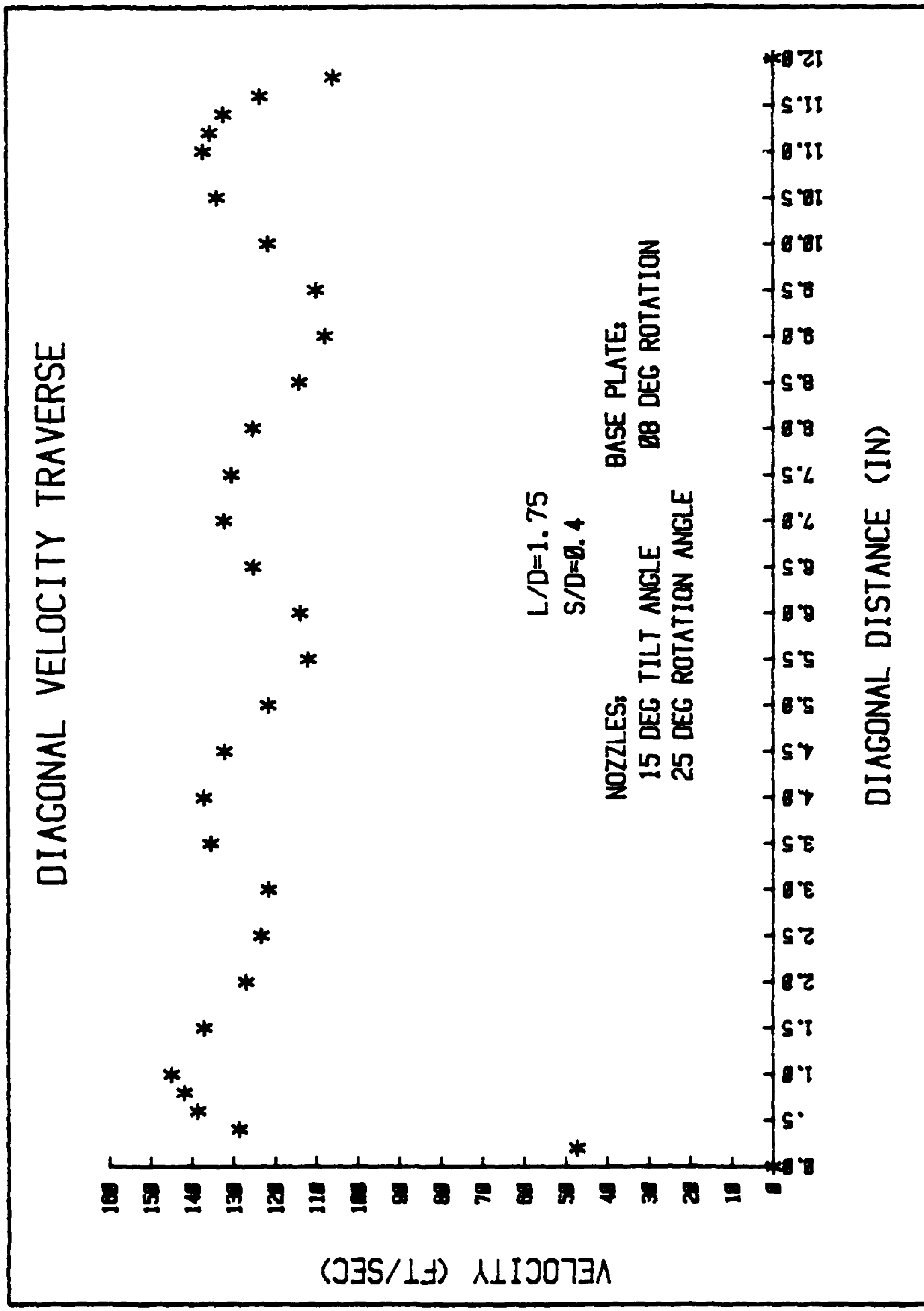
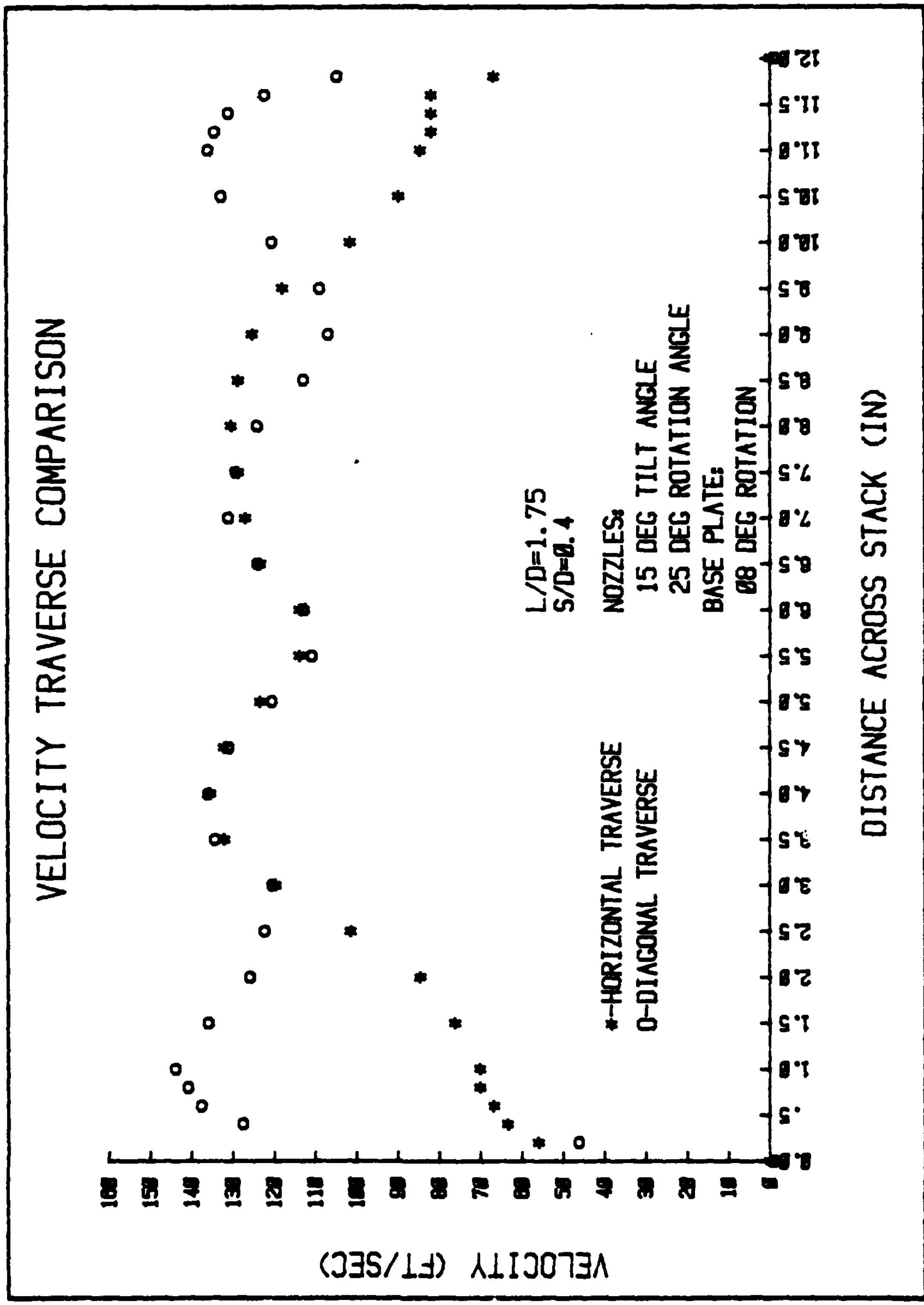

HORIZONTAL VELOCITY TRAVERSE
S/D=0.4 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
08 DEG ROTATION
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)

FIGURE 37.3



DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.4
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
00 DEG ROTATION
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0

FIGURE 37.4



VELOCITY TRAVERSE COMPARISON
L/D=1.75
S/D=Ø.4
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
Ø8 DEG ROTATION
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)

FIGURE 37.5

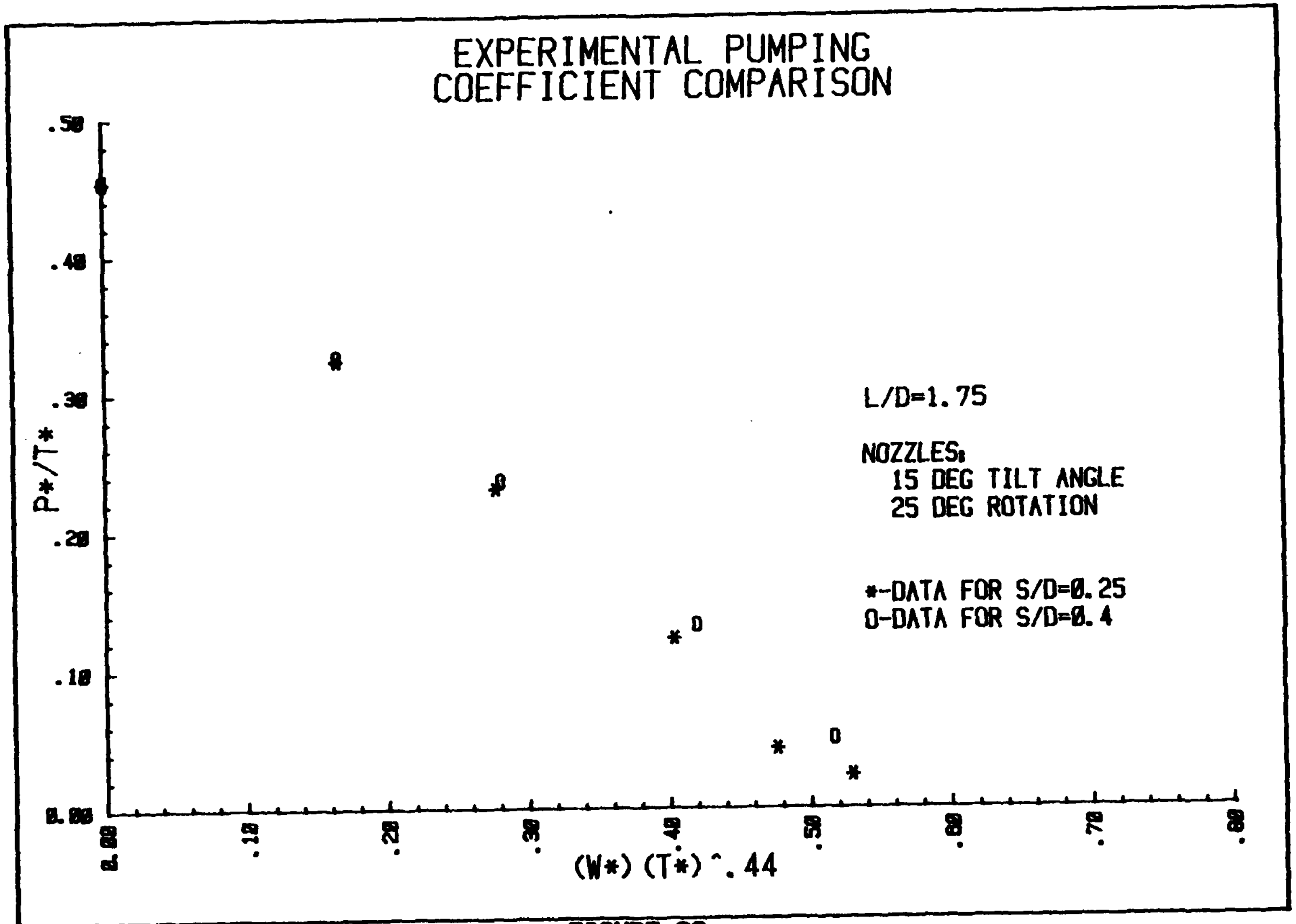

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
.50
.40
.30
.20
.10
0.00
P*/T*
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION
*-DATA FOR S/D=0.25
O-DATA FOR S/D=0.4

FIGURE 38

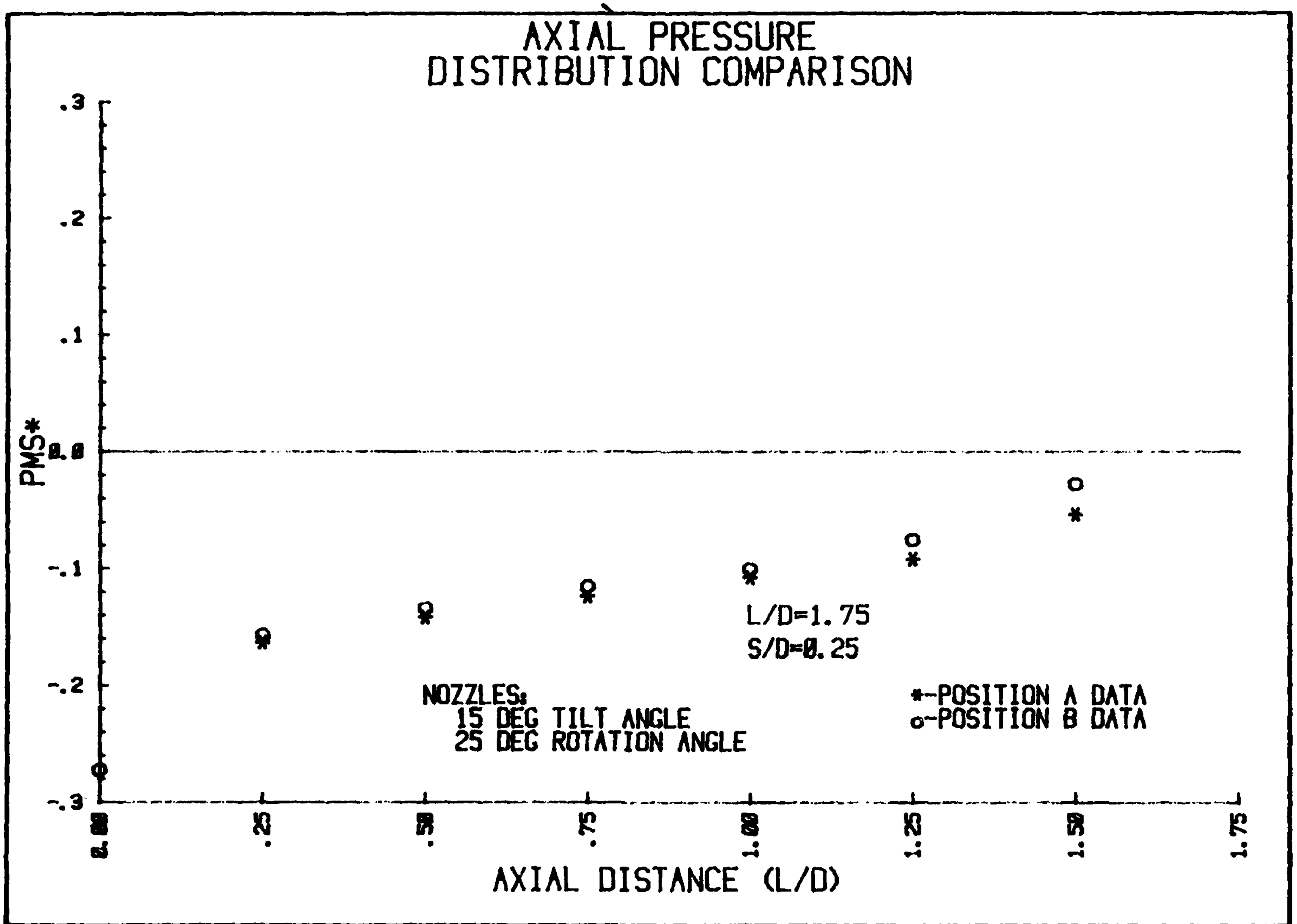
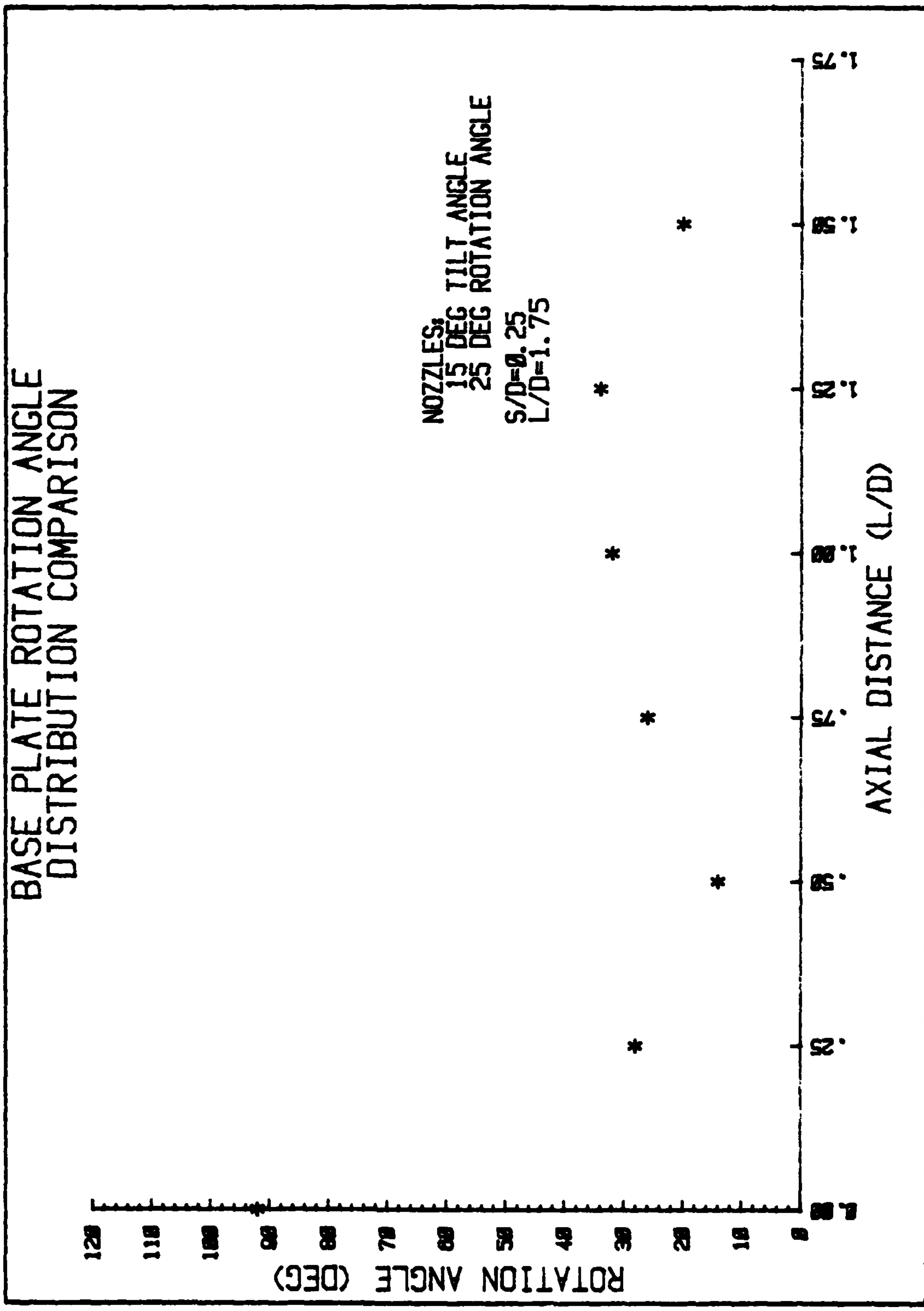

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
L/D=1.75
S/D=0.25
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA

FIGURE 38.1



BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
S/D=0.25
L/D=1.75
ROTATION ANGLE (DEG)
AXIAL DISTANCE (L/D)
0
10
20
30
40
50
60
70
80
90
100
110
120
0.00
.25
.50
.75
1.00
1.25
1.50
1.75

FIGURE 30.2

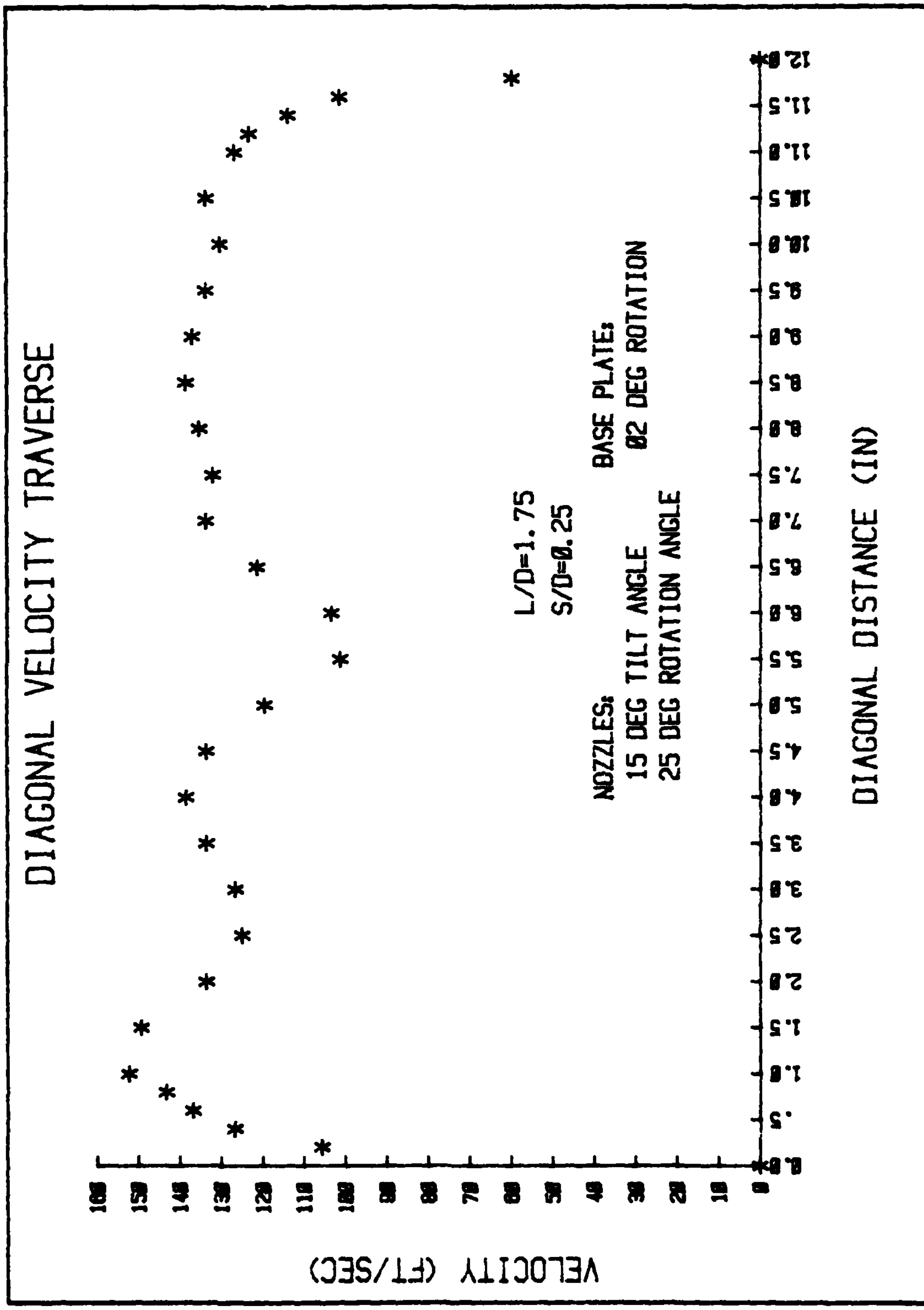

DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=Ø.25
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
Ø2 DEG ROTATION
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)

FIGURE 38.3

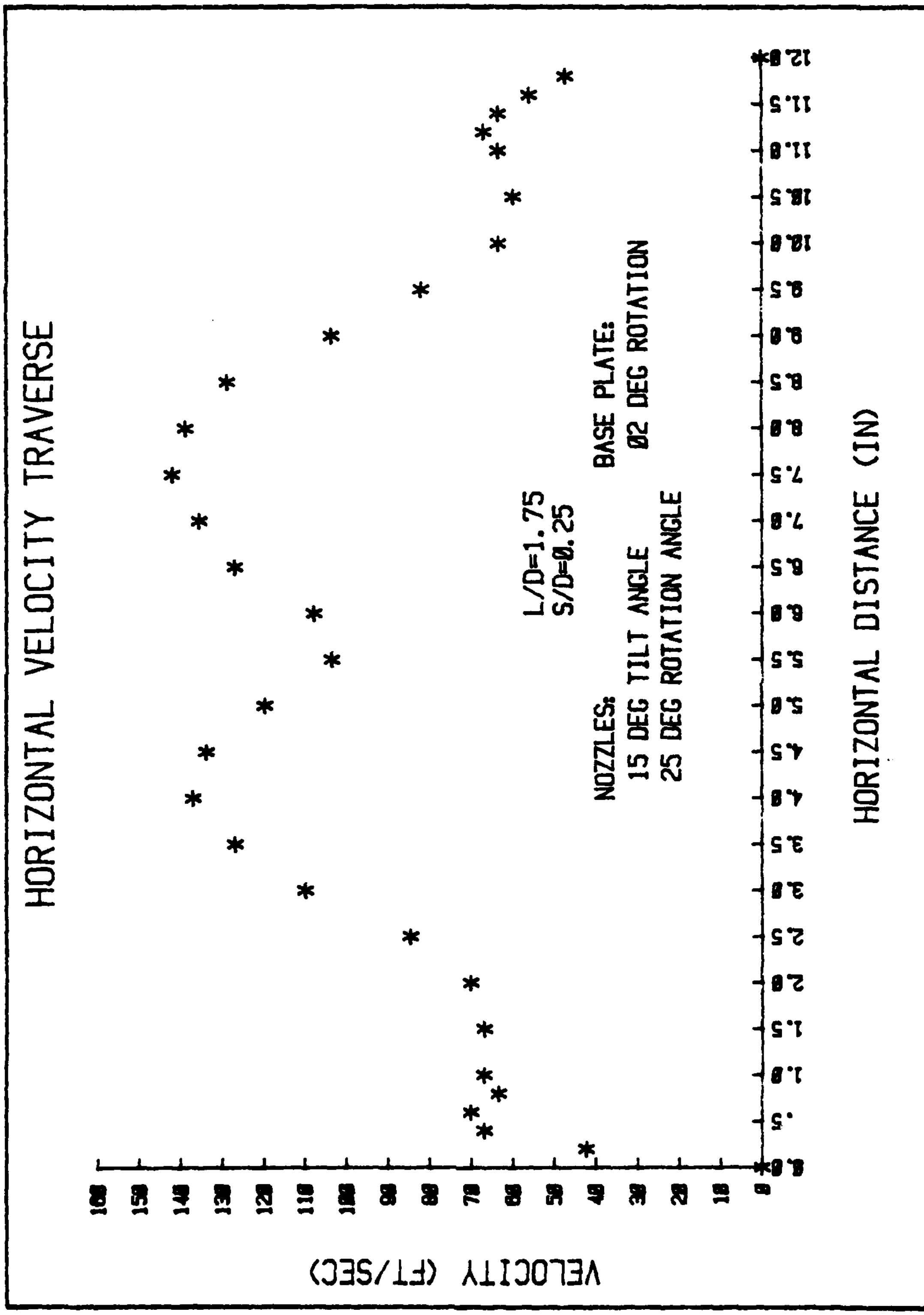

HORIZONTAL VELOCITY TRAVERSE
L/D=1.75
S/D=Ø.25
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
Ø2 DEG ROTATION
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0

FIGURE 38.4

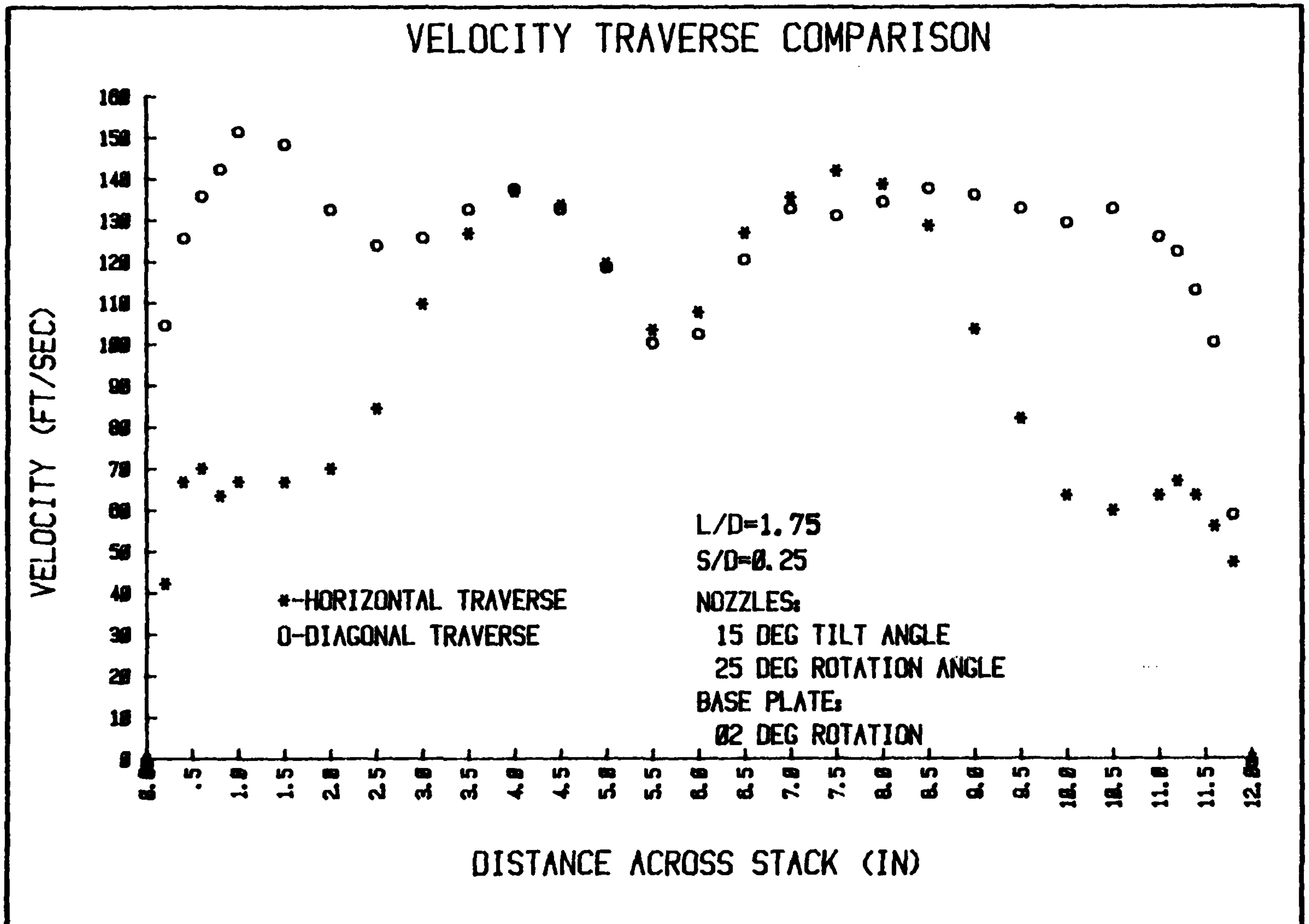
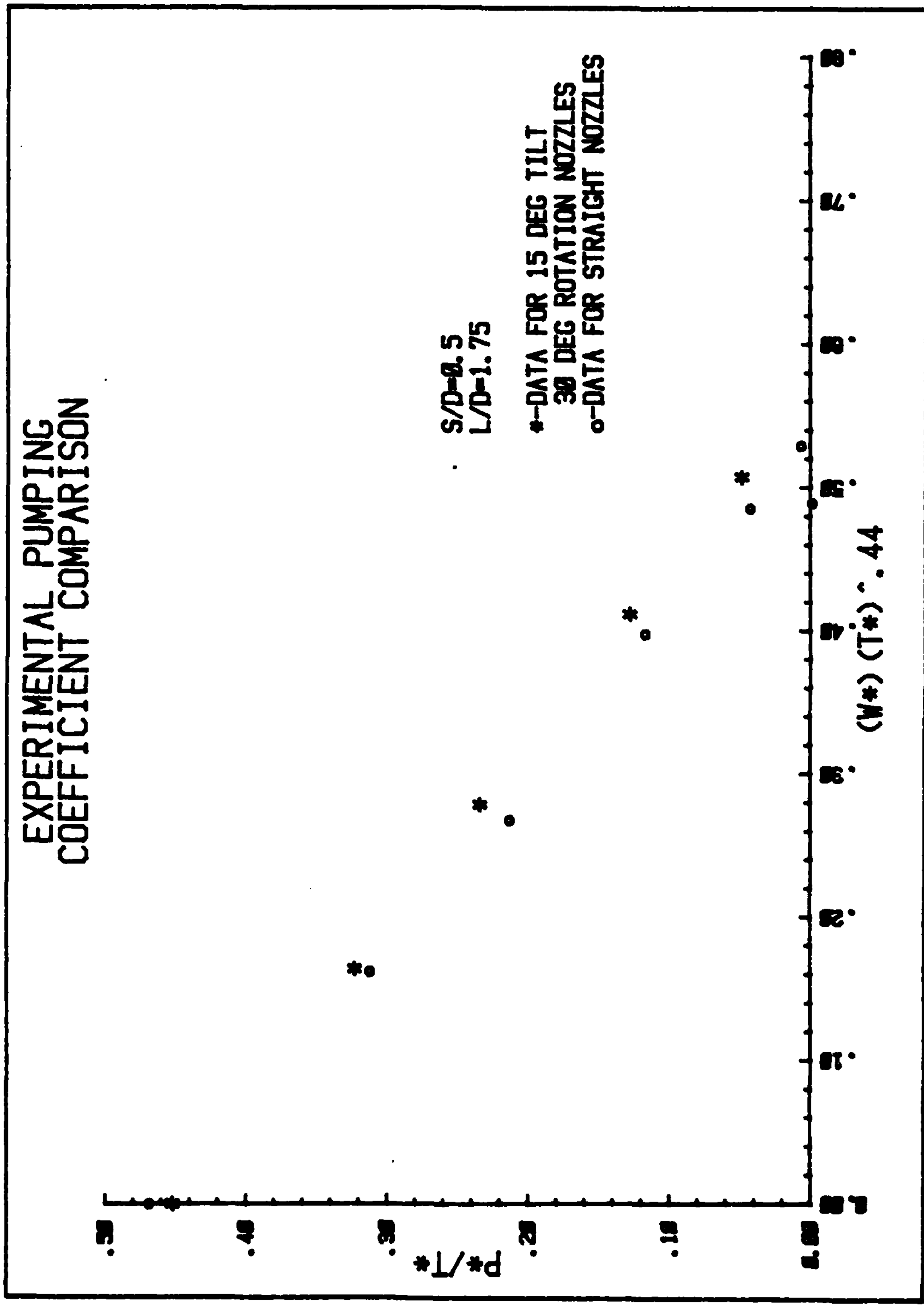

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.75
S/D=0.25
NOZZLES:
15 DEG TILT ANGLE
25 DEG ROTATION ANGLE
BASE PLATE:
02 DEG ROTATION

FIGURE 38.5



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 39

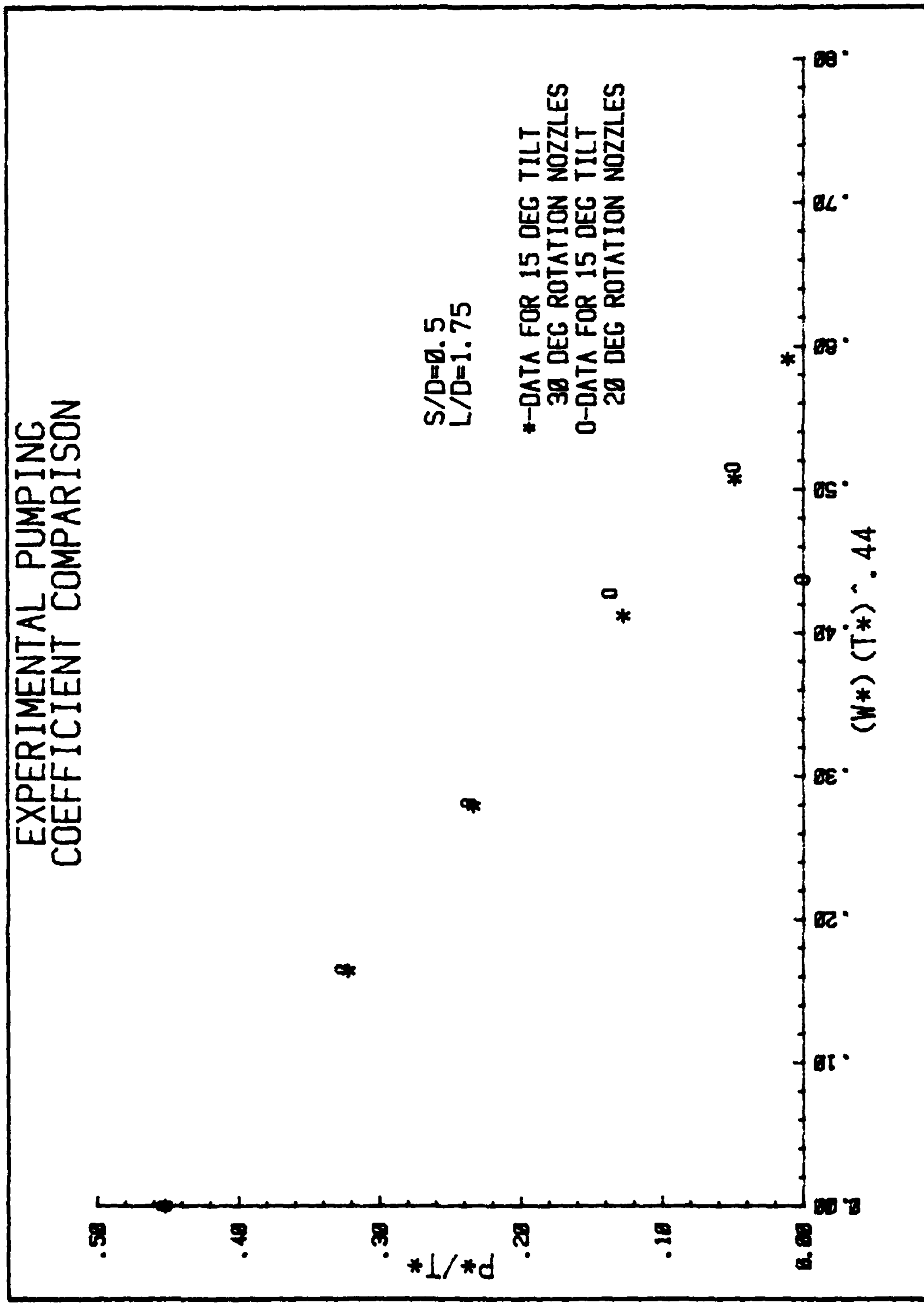

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
O-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 30.1

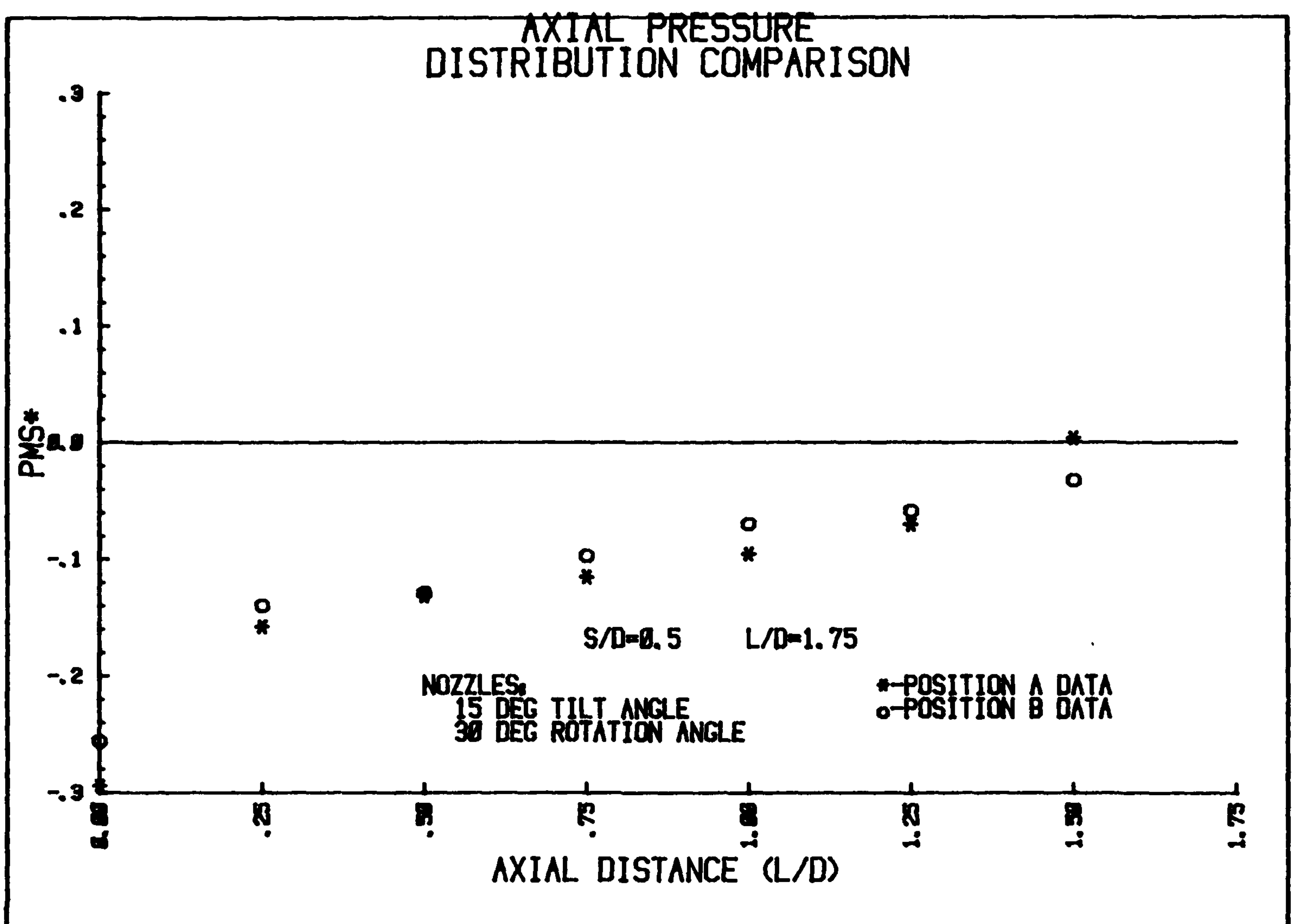

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
S/D=0.5 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
30 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 30.2

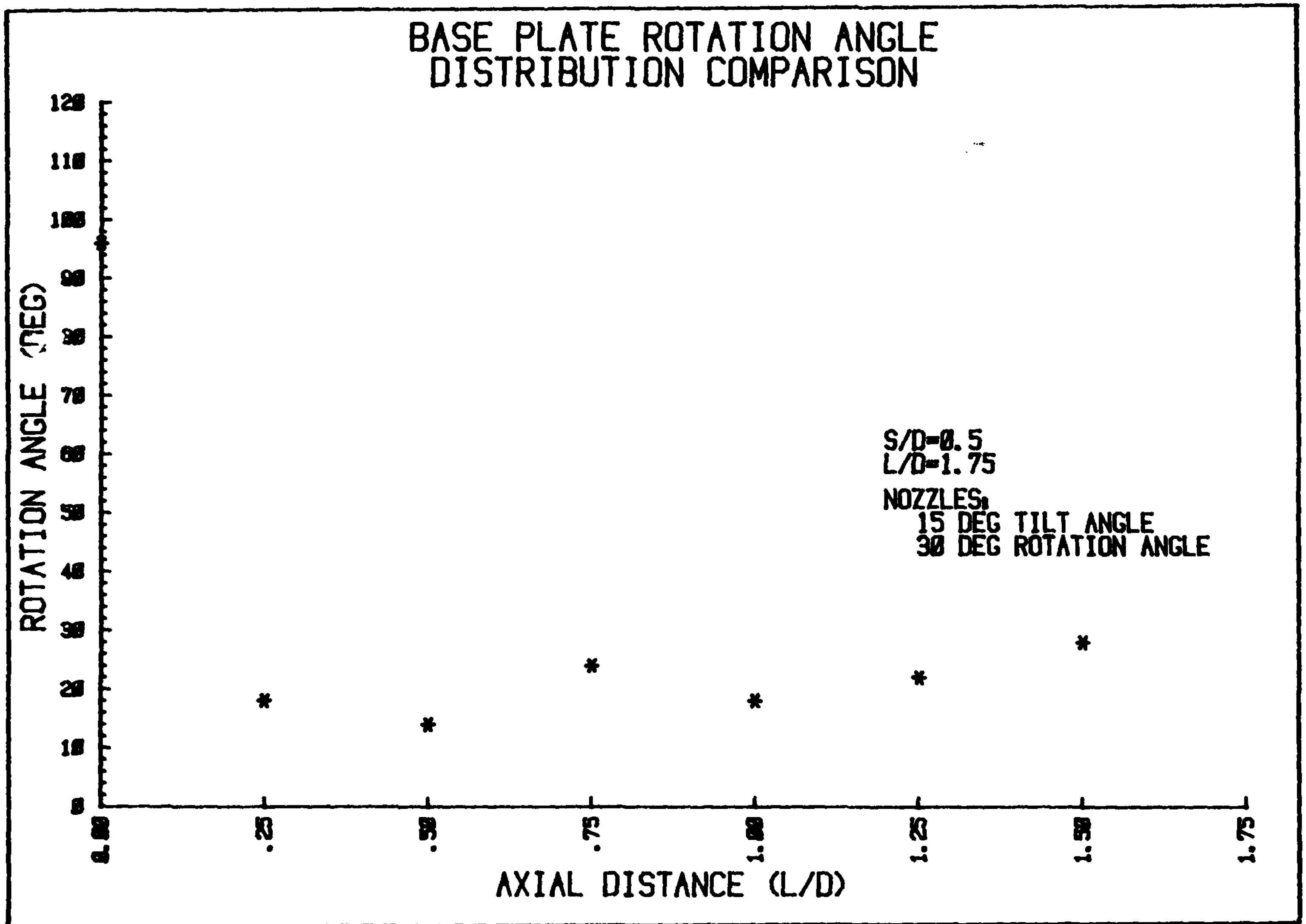

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
AXIAL DISTANCE (L/D)
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
S/D=0.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
30 DEG ROTATION ANGLE

FIGURE 30.3

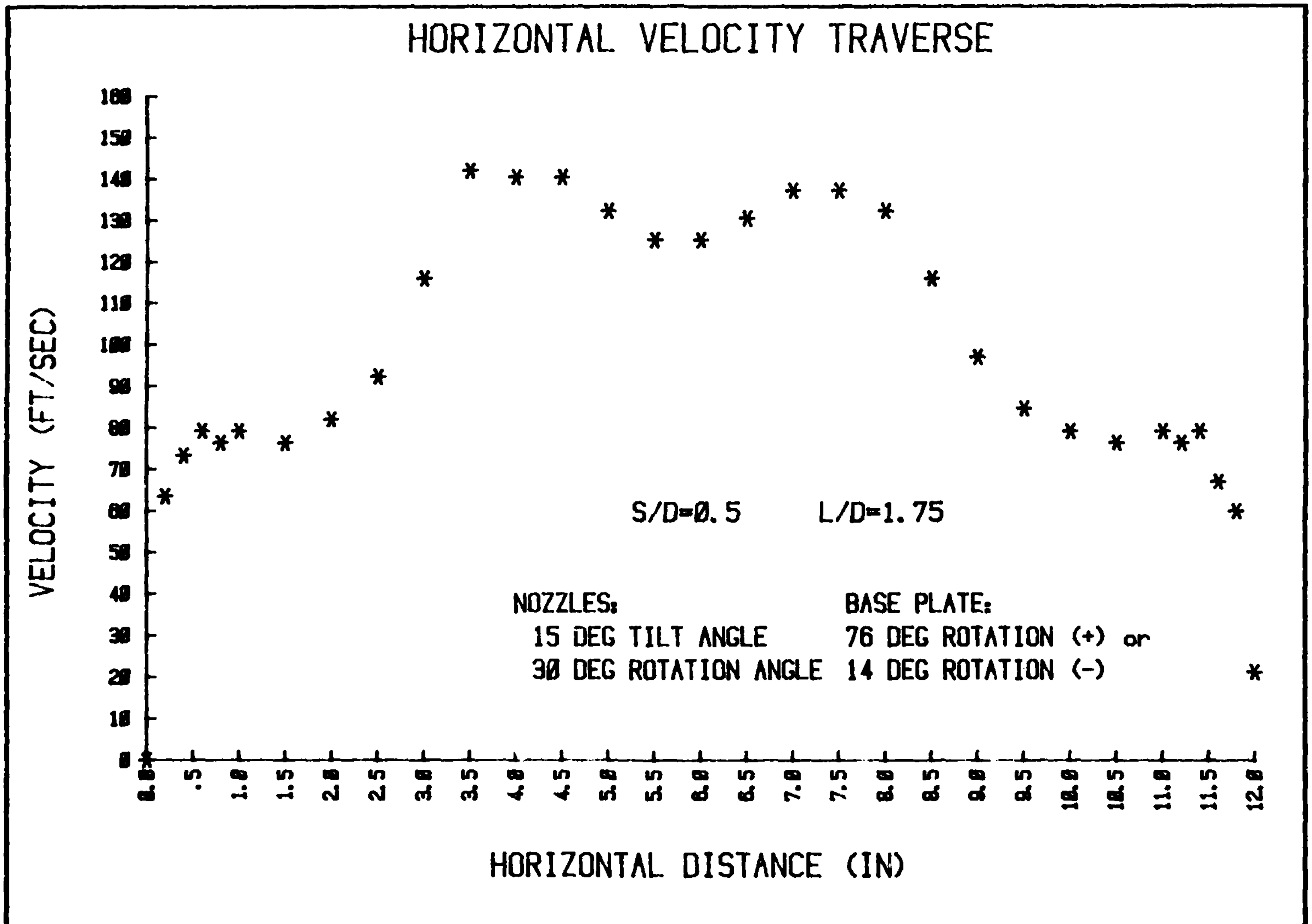

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
S/D=0.5 L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
30 DEG ROTATION ANGLE
BASE PLATE:
76 DEG ROTATION (+) or
14 DEG ROTATION (-)

FIGURE 30.4

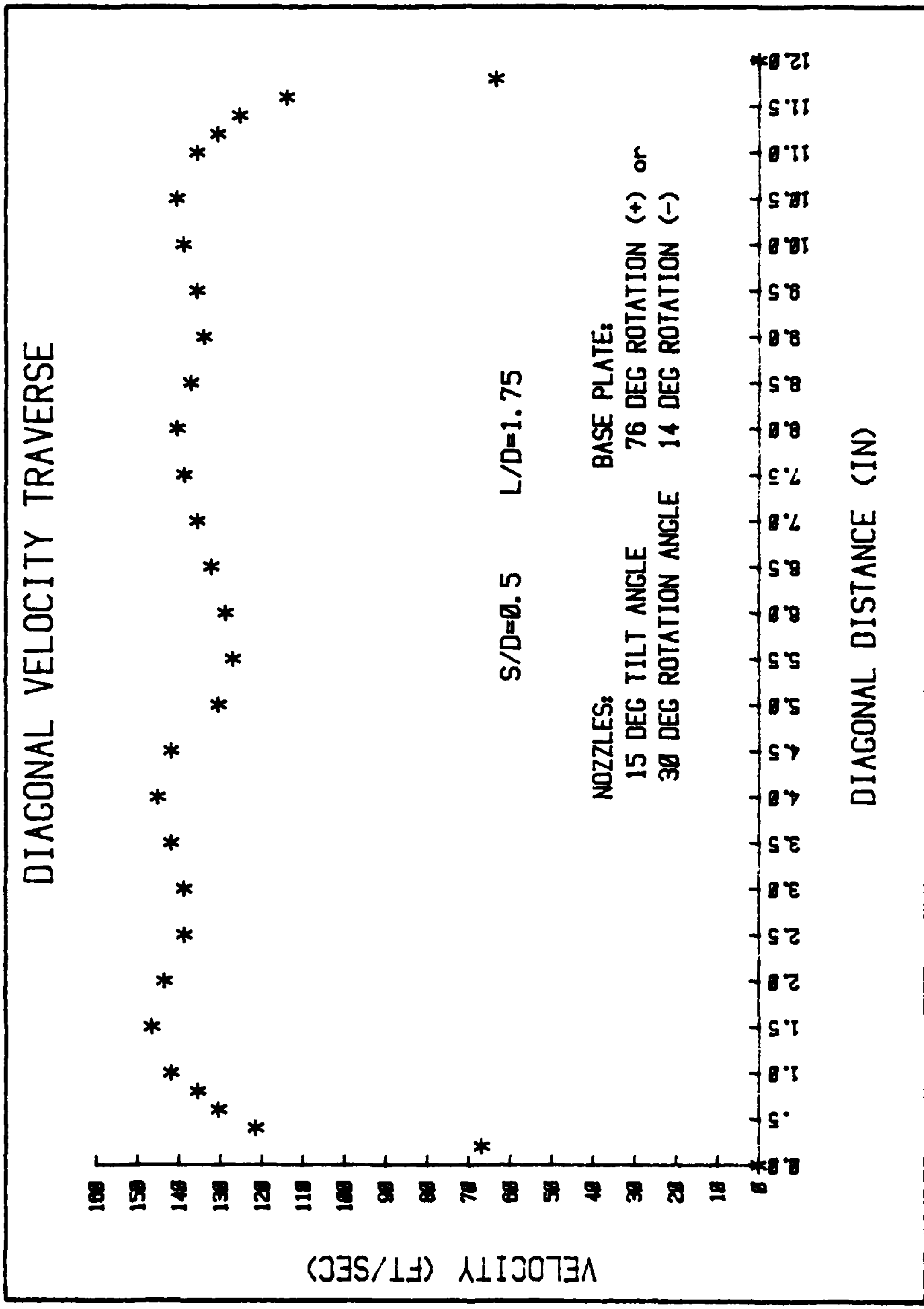
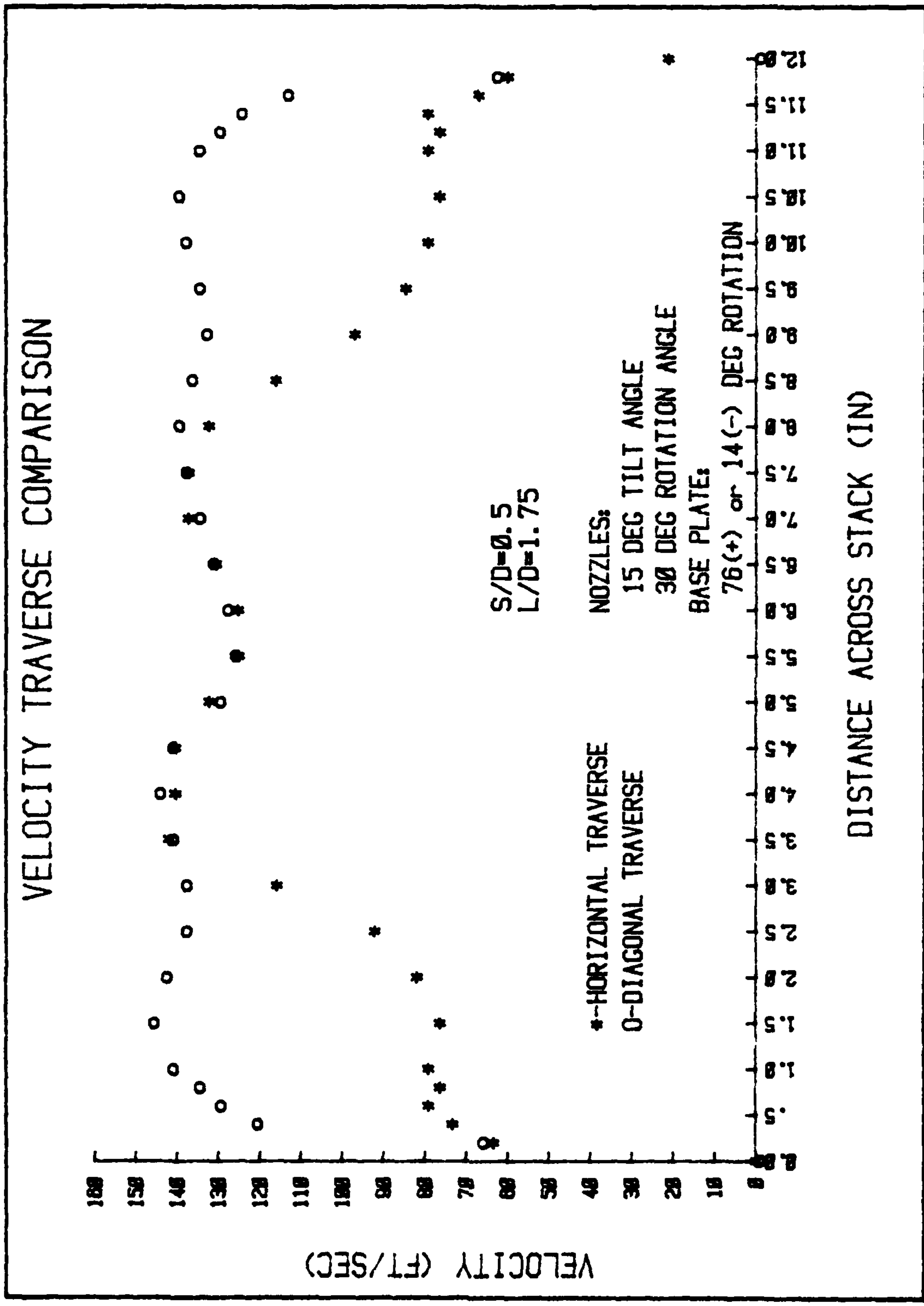

DIAGONAL VELOCITY TRAVERSE
S/D=Ø.5 L/D=1.75
BASE PLATE:
76 DEG ROTATION (+) or
14 DEG ROTATION (-)
NOZZLES:
15 DEG TILT ANGLE
3Ø DEG ROTATION ANGLE
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)
0.0 .5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160

FIGURE 30.5



VELOCITY TRAVERSE COMPARISON
S/D=Ø.5
L/D=1.75
NOZZLES:
15 DEG TILT ANGLE
3Ø DEG ROTATION ANGLE
BASE PLATE:
76(+) or 14(-) DEG ROTATION
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)

FIGURE 39.6

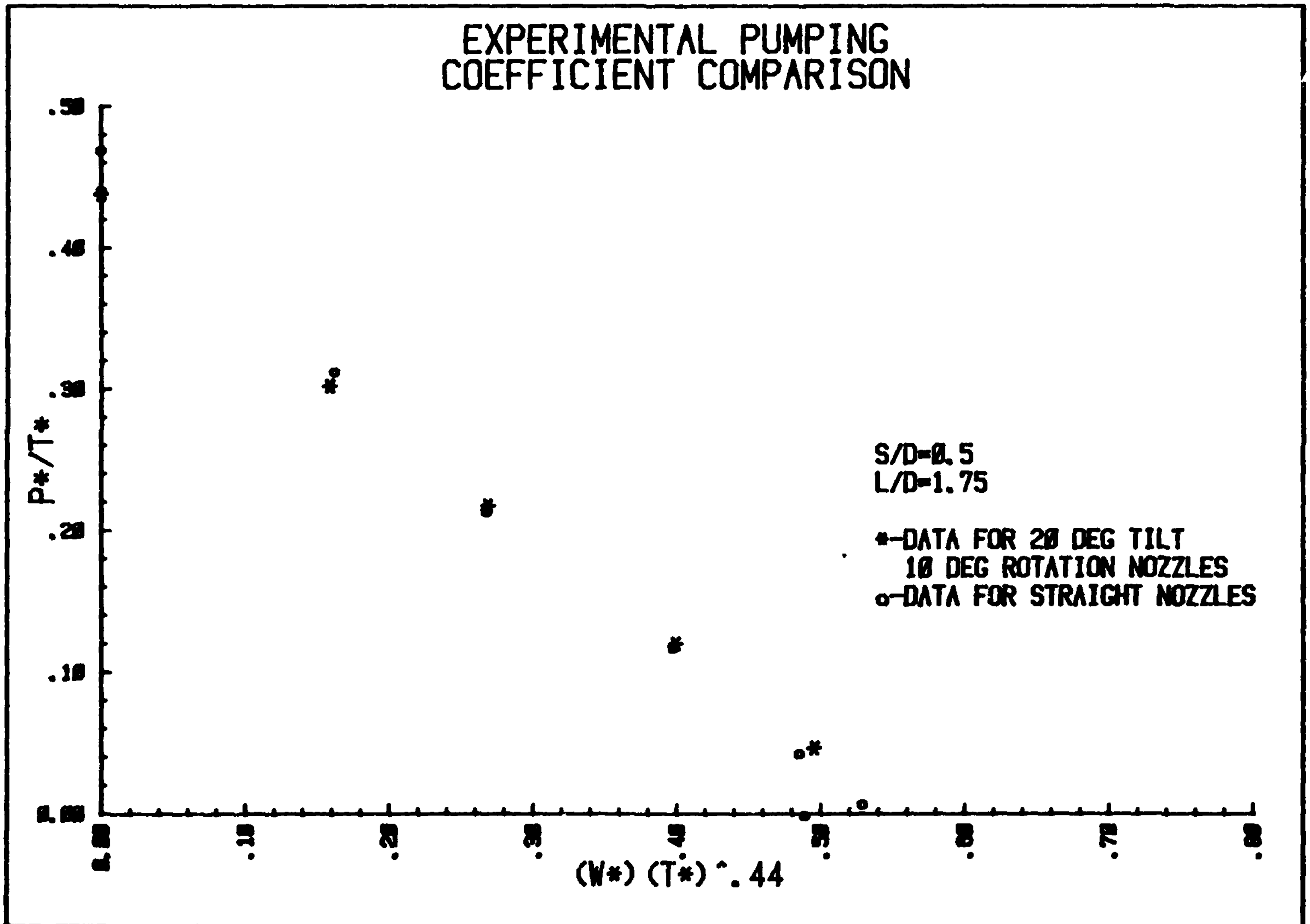
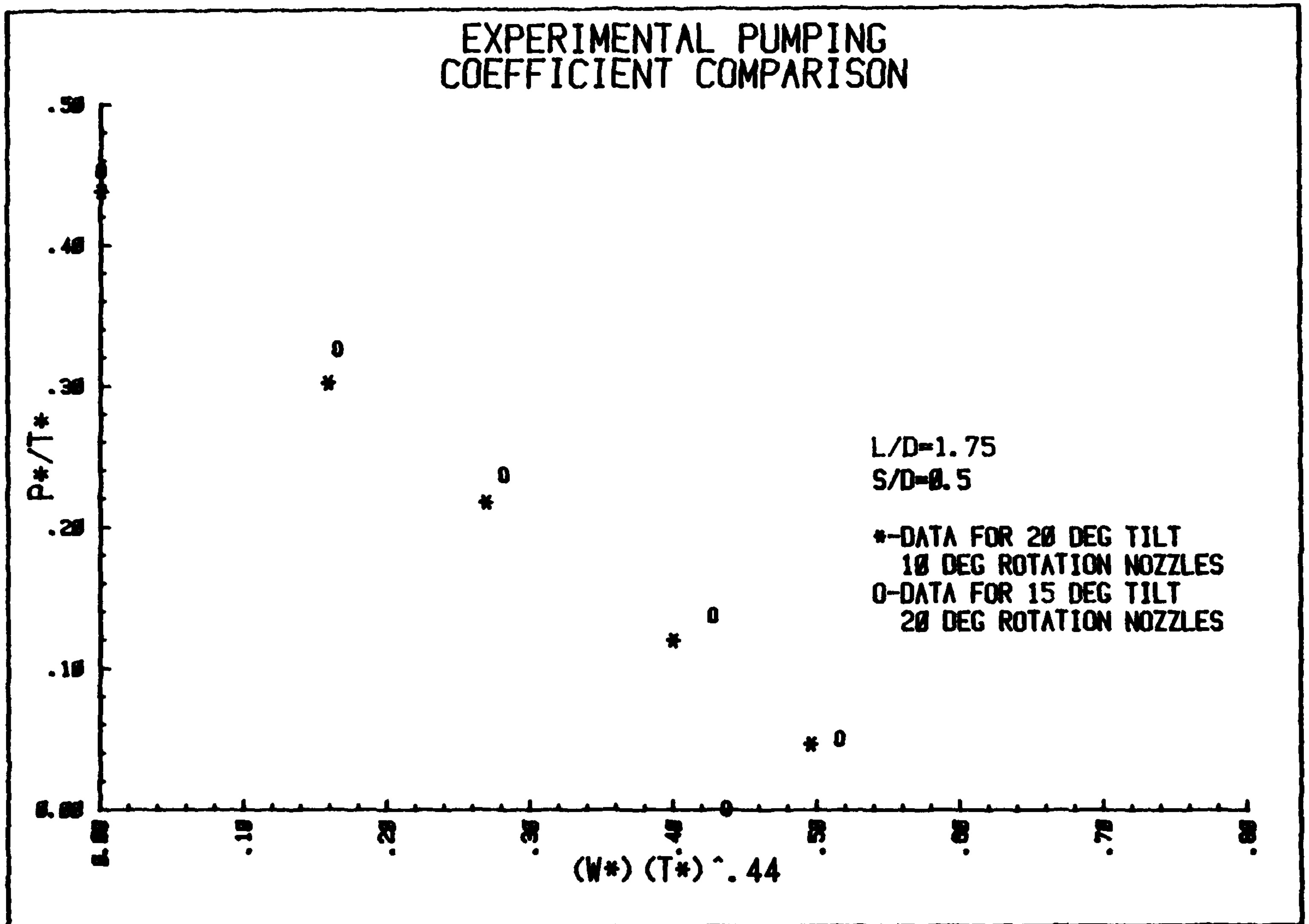
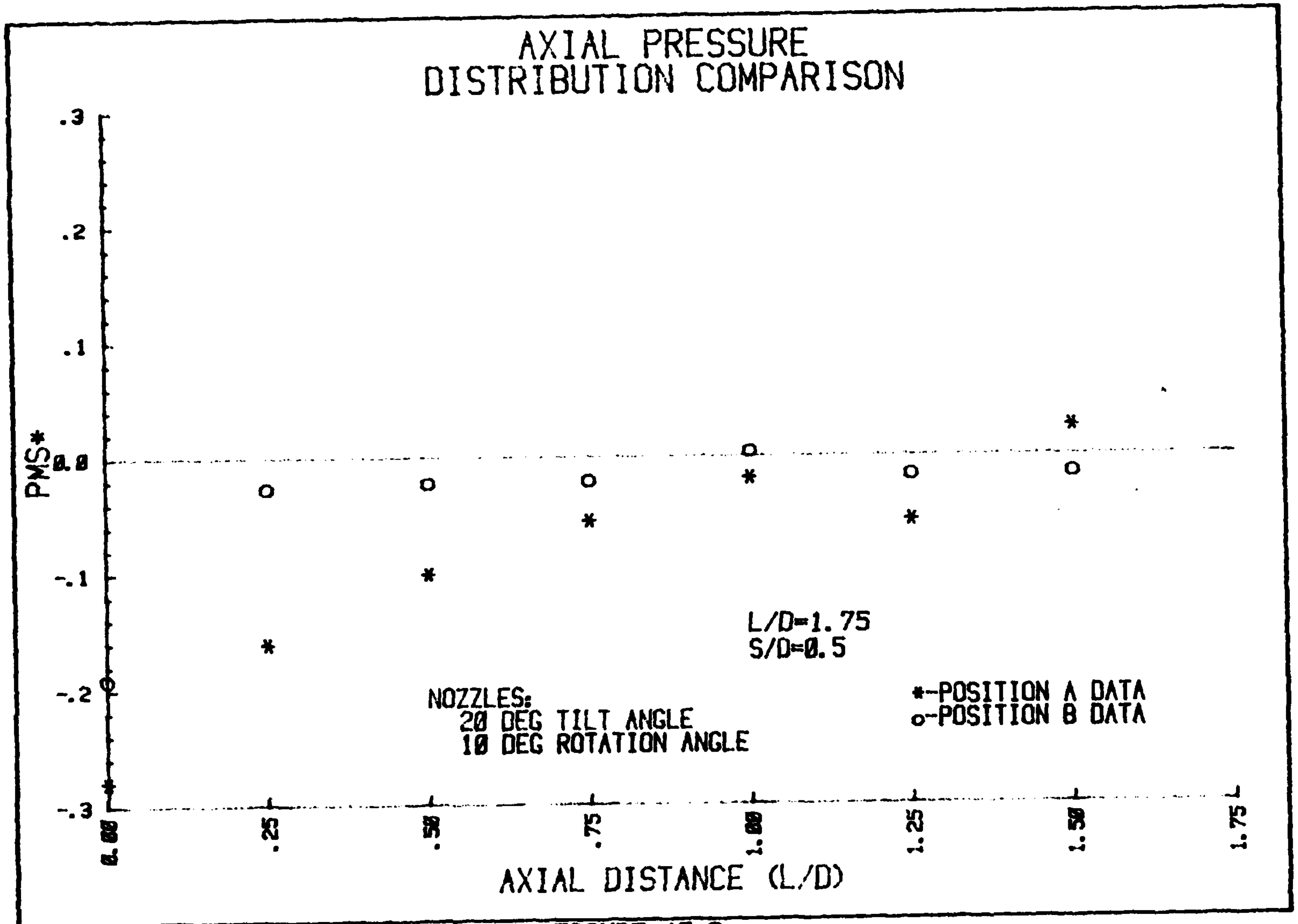

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 40



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
L/D=1.75
S/D=0.5
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
O-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 40.1



AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
10 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA

FIGURE 40.2

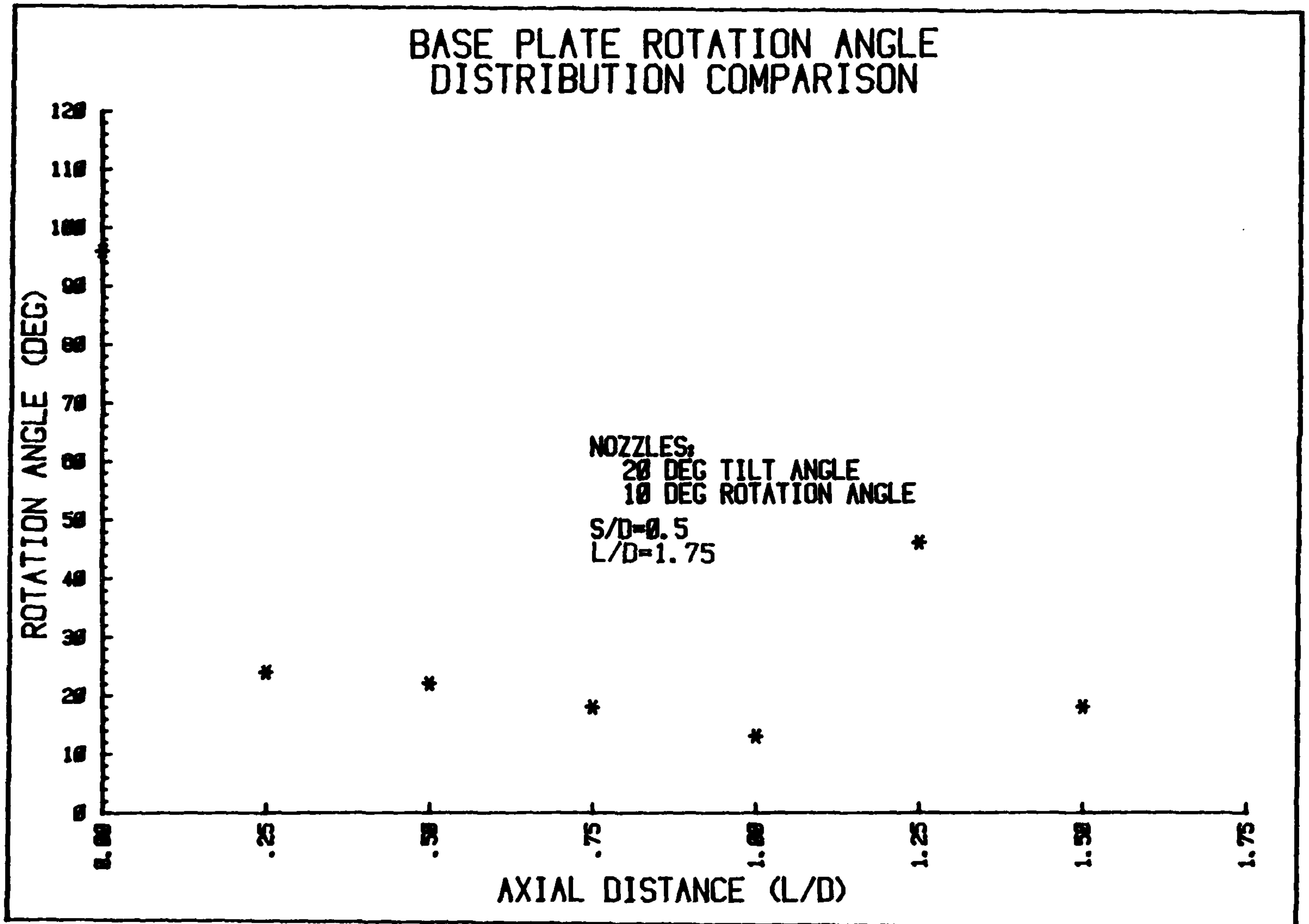

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
ROTATION ANGLE (DEG)
120
110
100
90
80
70
60
50
40
30
20
10
0
NOZZLES;
20 DEG TILT ANGLE
10 DEG ROTATION ANGLE
S/D=0.5
L/D=1.75
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 40.3

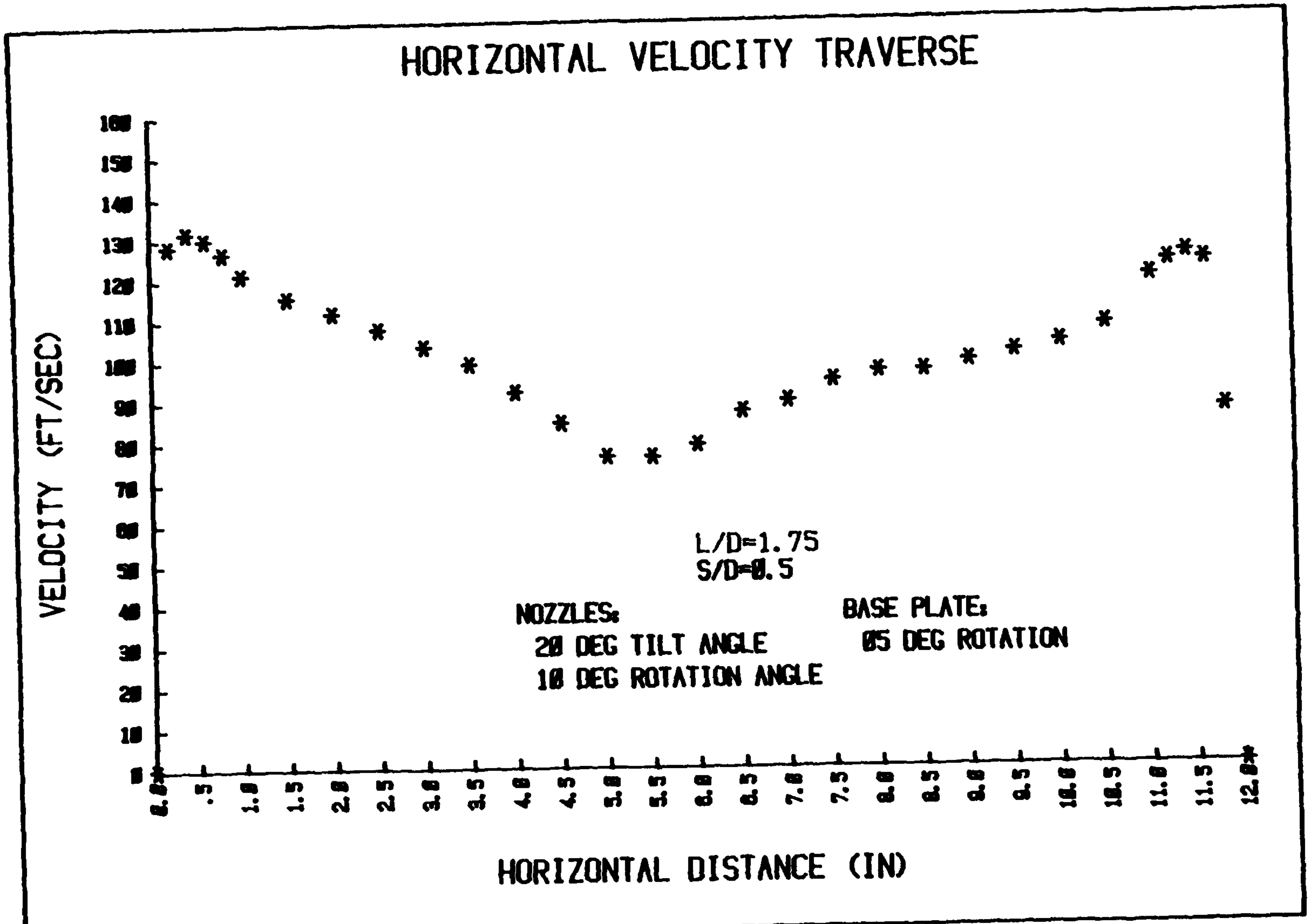

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
HORIZONTAL DISTANCE (IN)
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
10 DEG ROTATION ANGLE
BASE PLATE:
05 DEG ROTATION

FIGURE 40.4

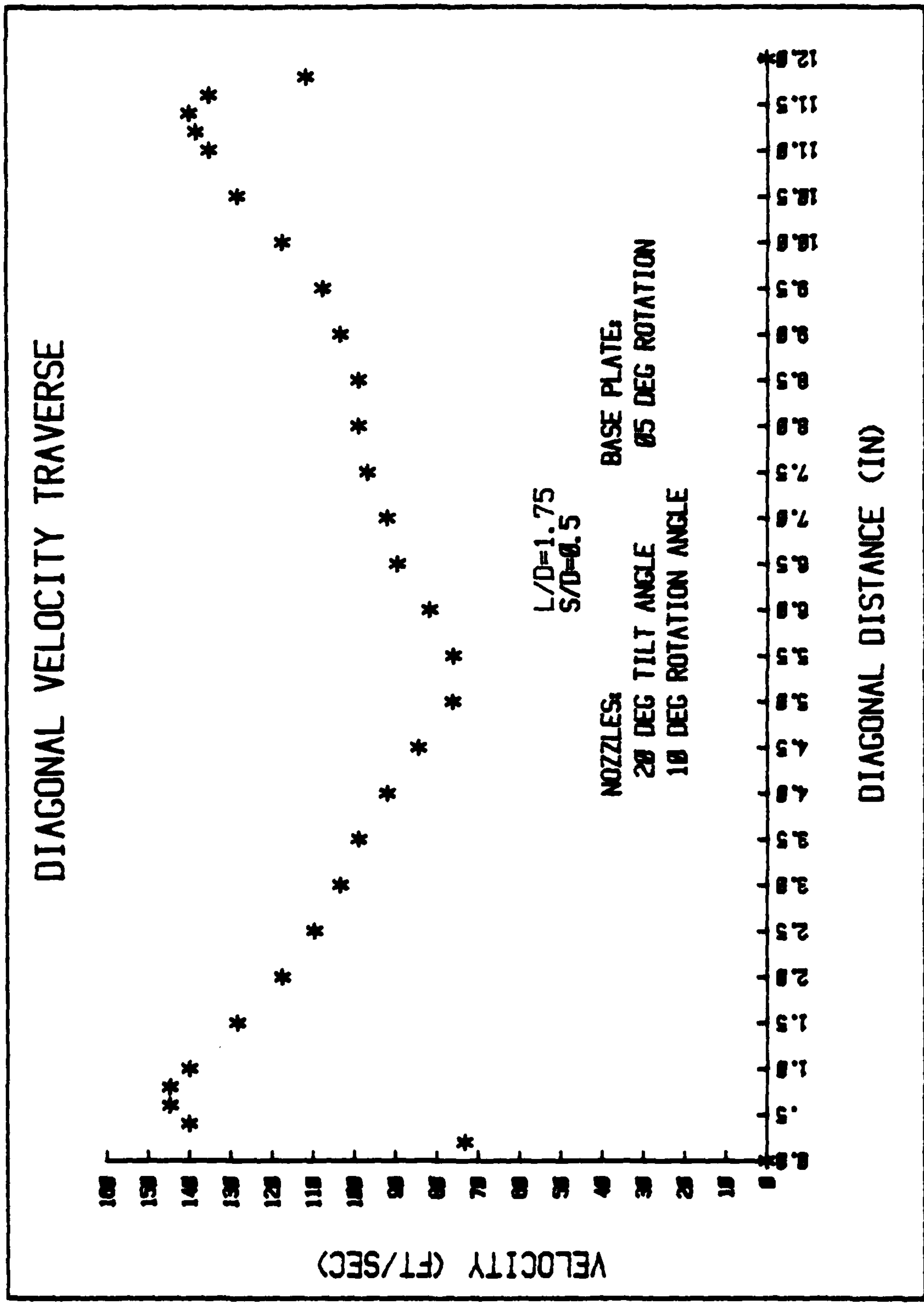

DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
10 DEG ROTATION ANGLE
BASE PLATE:
05 DEG ROTATION
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)

FIGURE 40.5

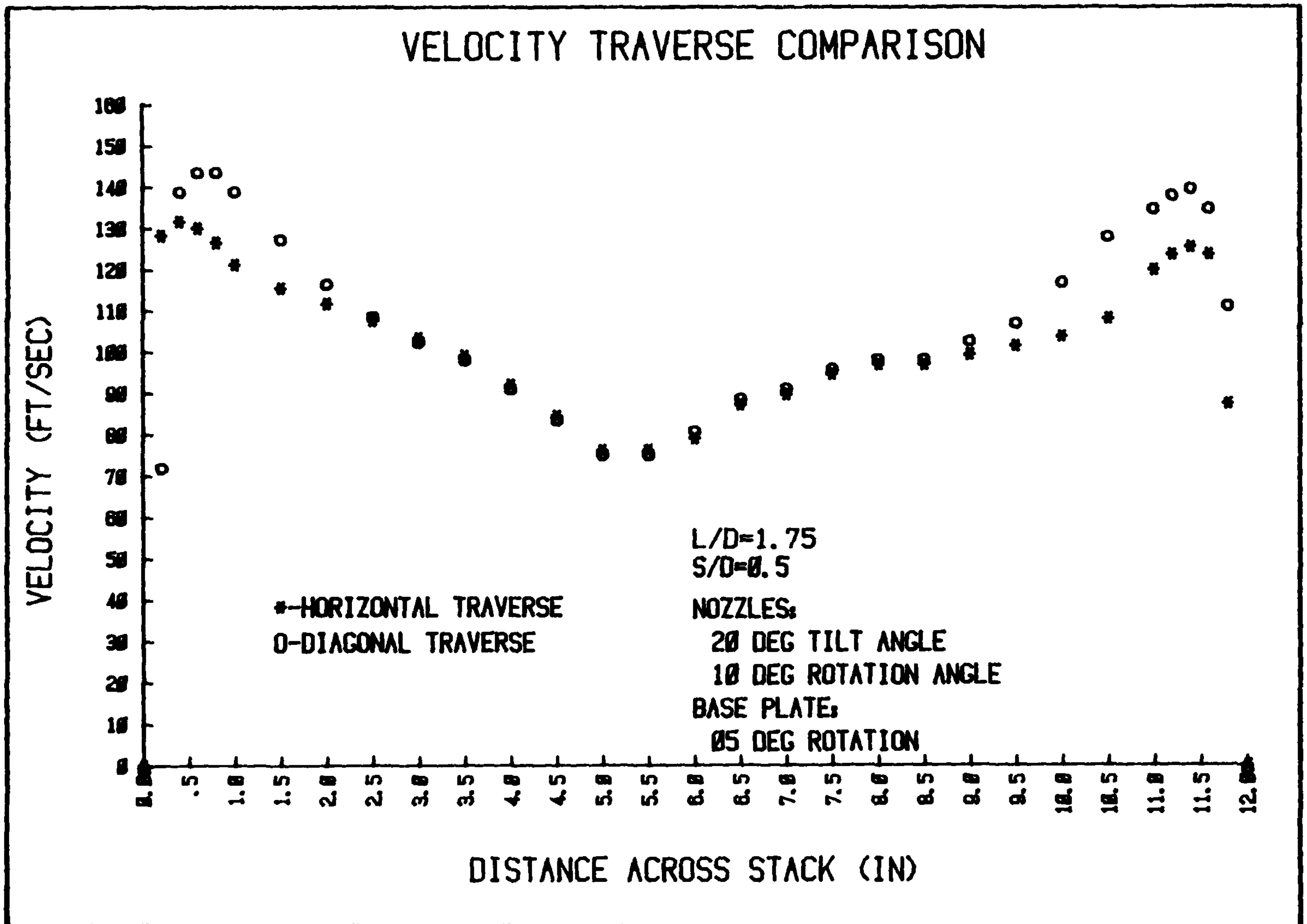

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
10 DEG ROTATION ANGLE
BASE PLATE:
05 DEG ROTATION

FIGURE 40.6

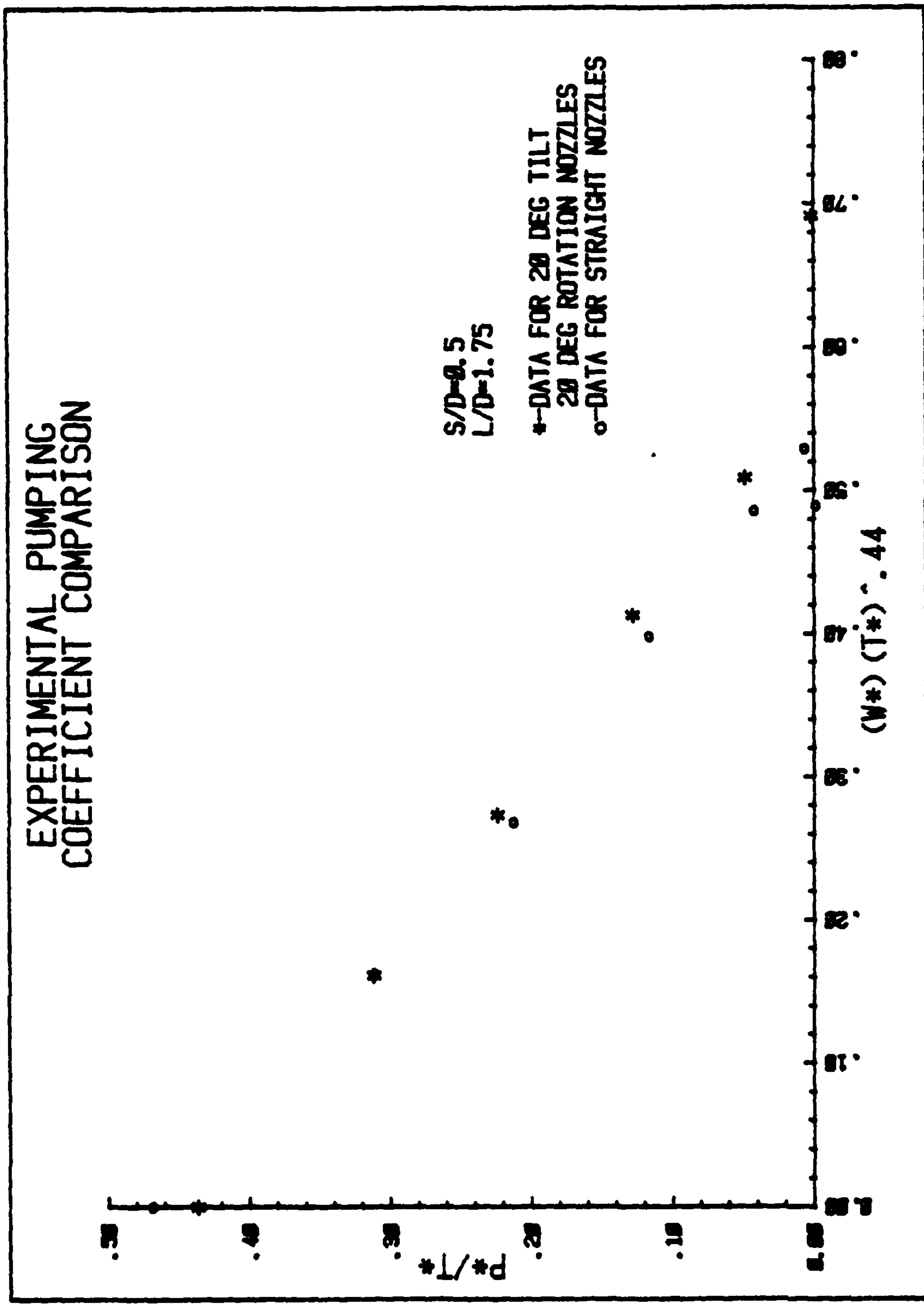

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 20 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44

FIGURE 41

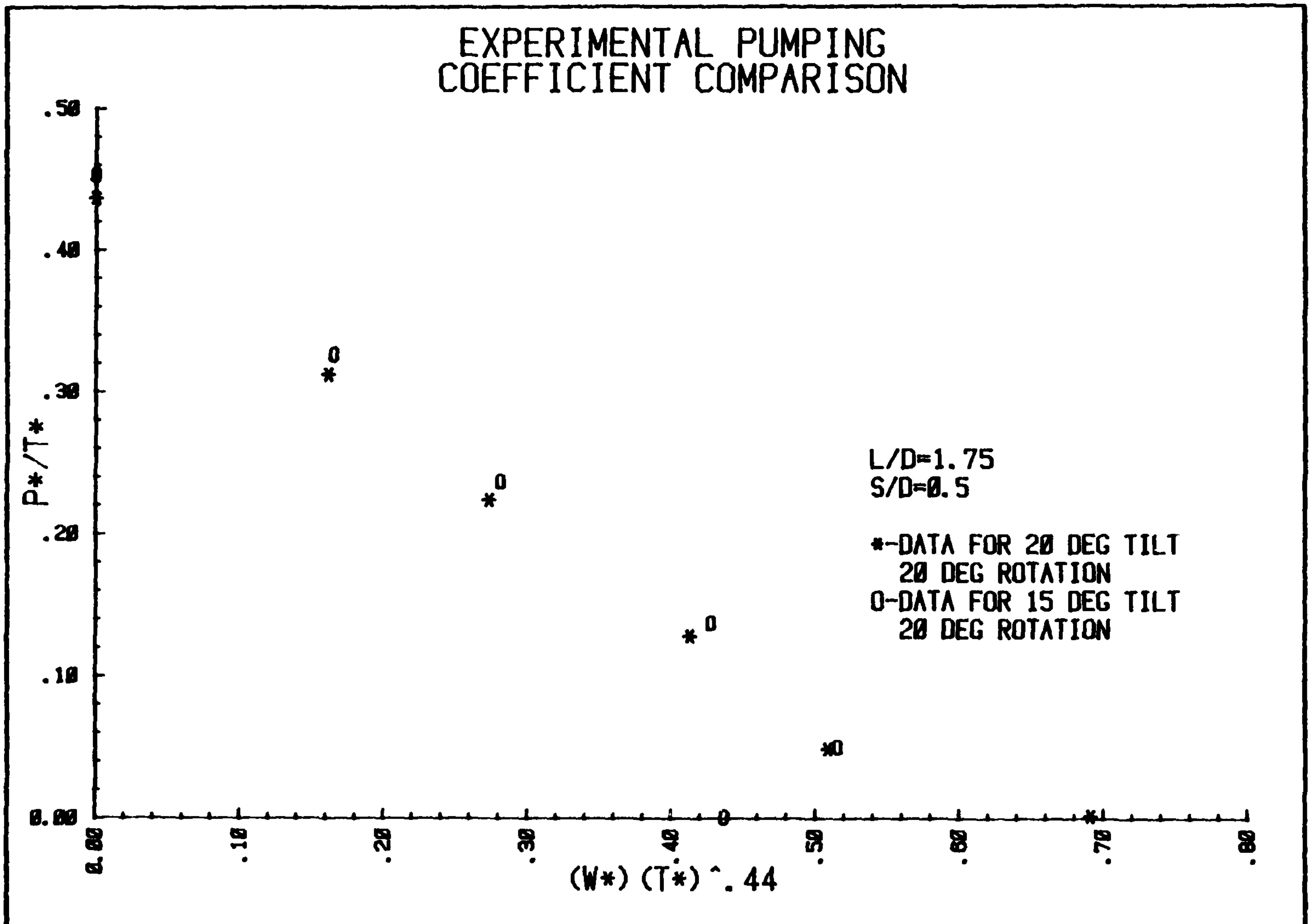

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
L/D=1.75
S/D=0.5
*-DATA FOR 20 DEG TILT
20 DEG ROTATION
O-DATA FOR 15 DEG TILT
20 DEG ROTATION
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44

FIGURE 41.1

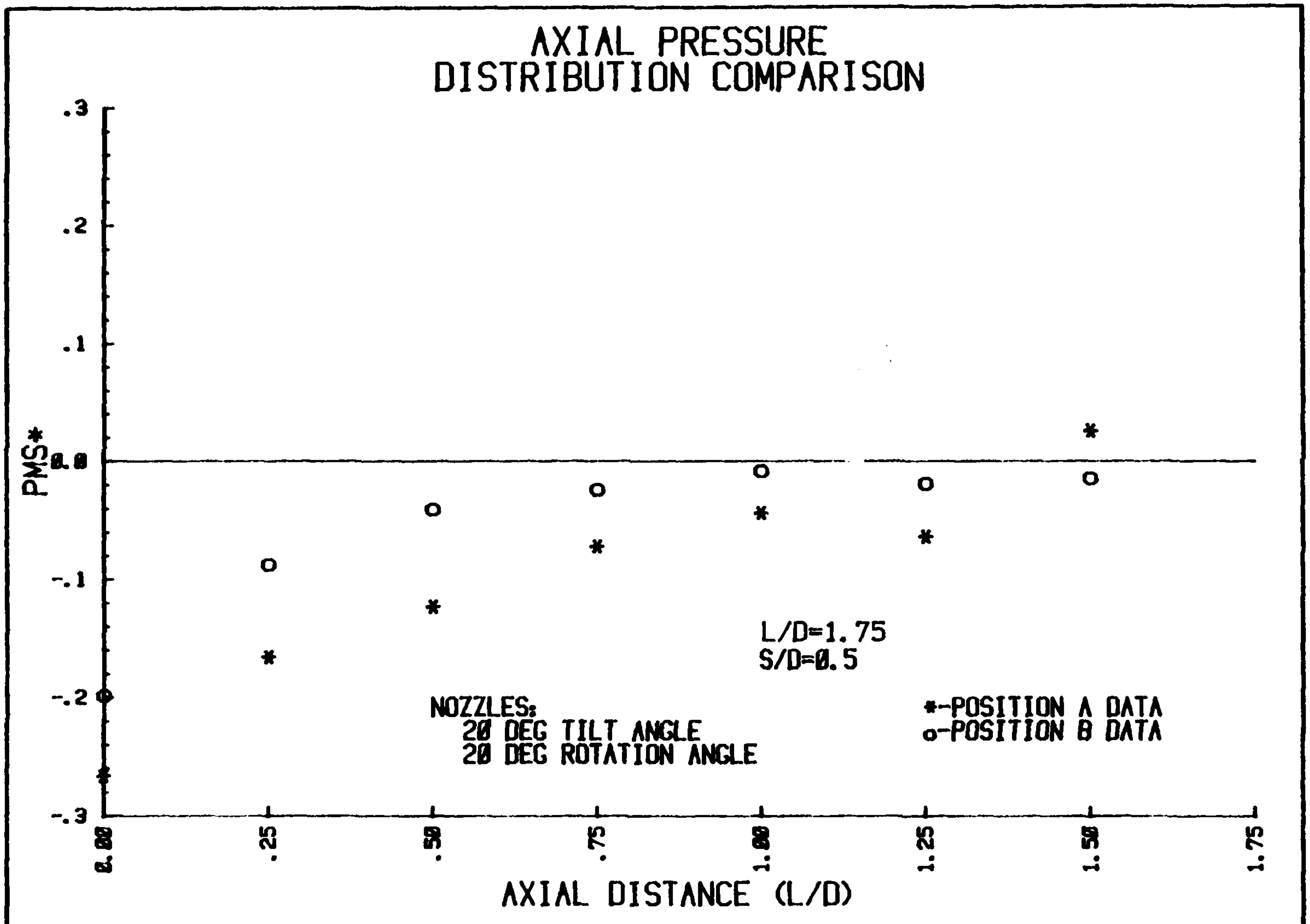

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA

FIGURE 41.2

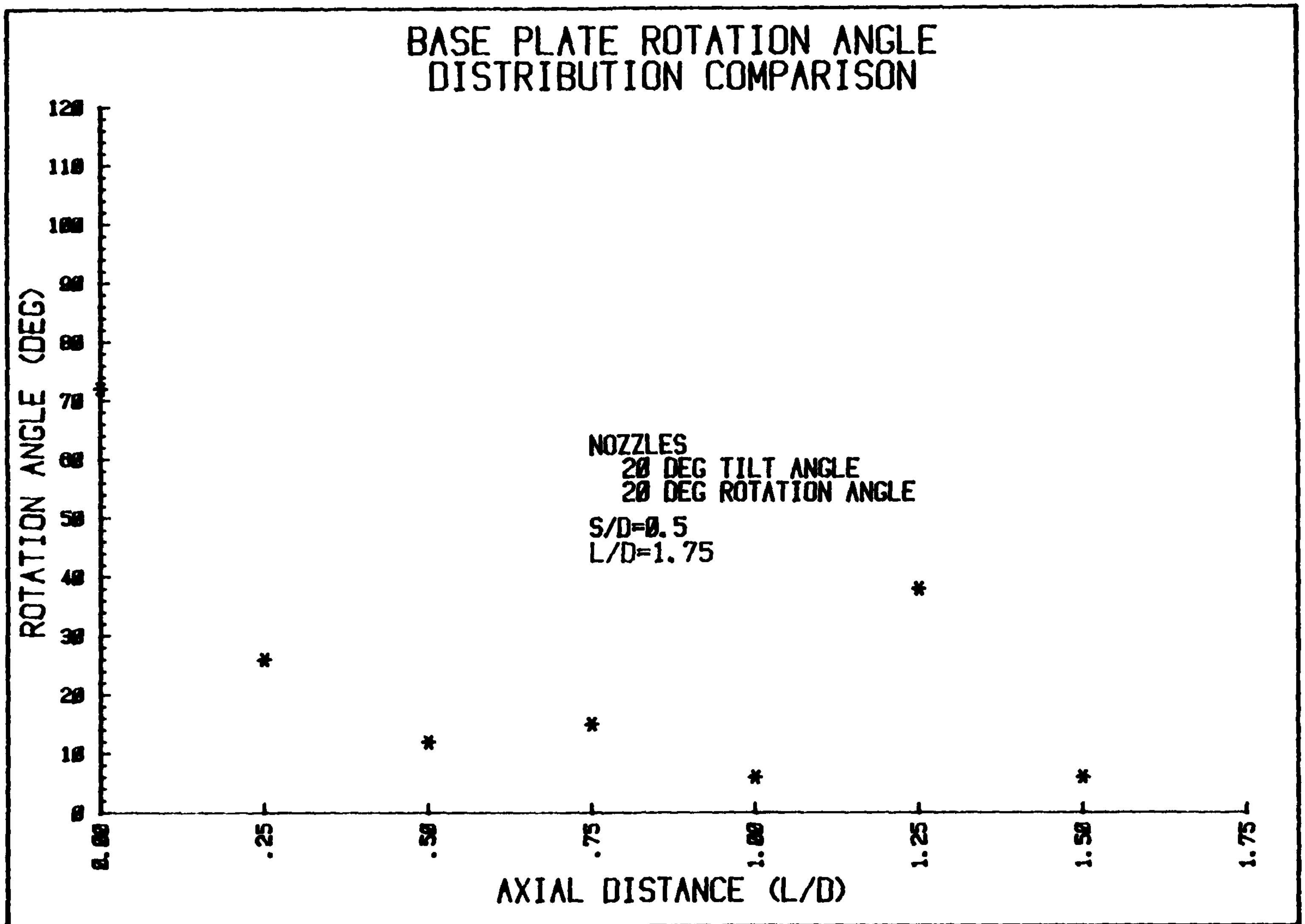

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
NOZZLES
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
S/D=0.5
L/D=1.75
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
AXIAL DISTANCE (L/D)
0.00
.25
.50
.75
1.00
1.25
1.50
1.75

FIGURE 41.3

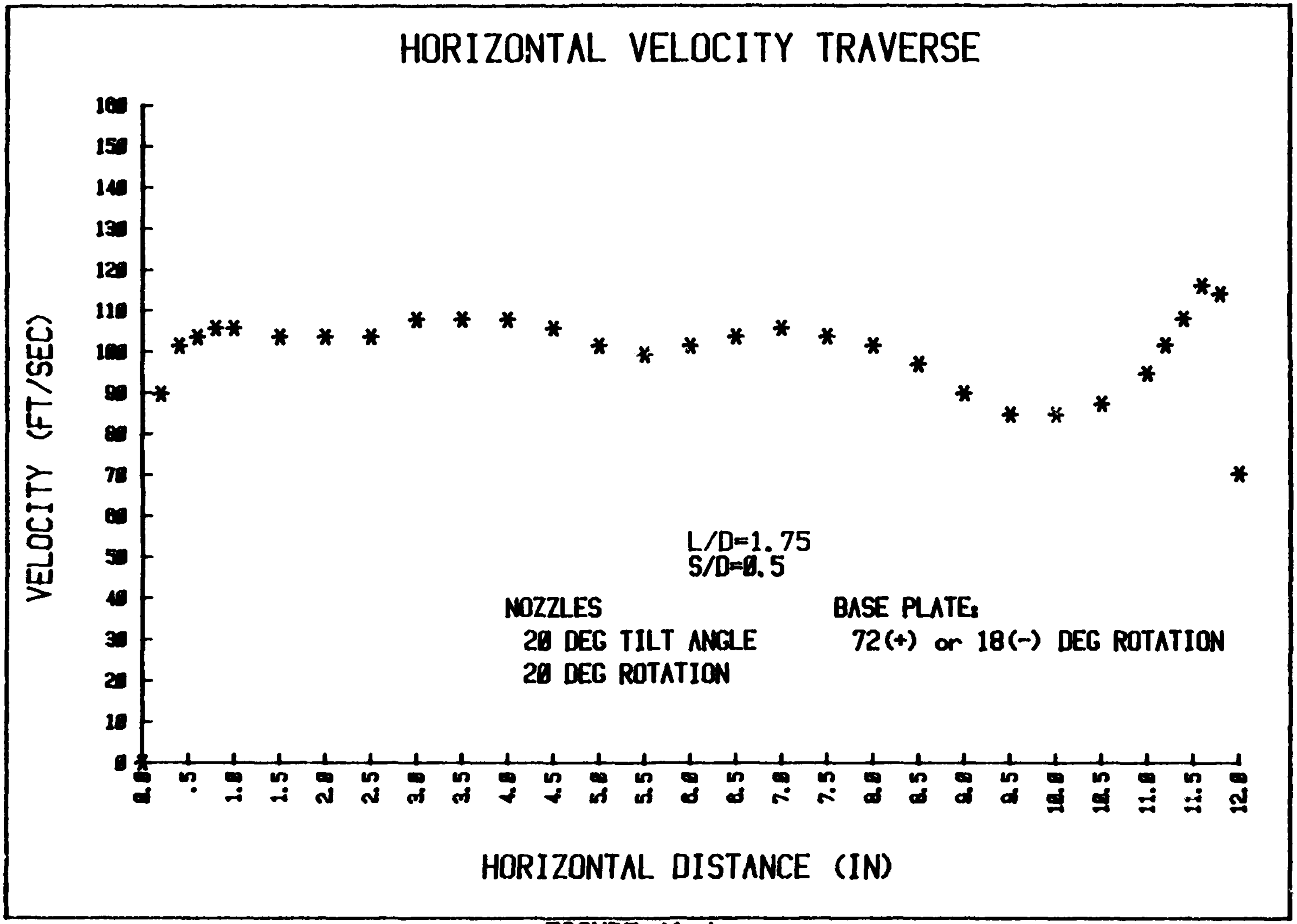
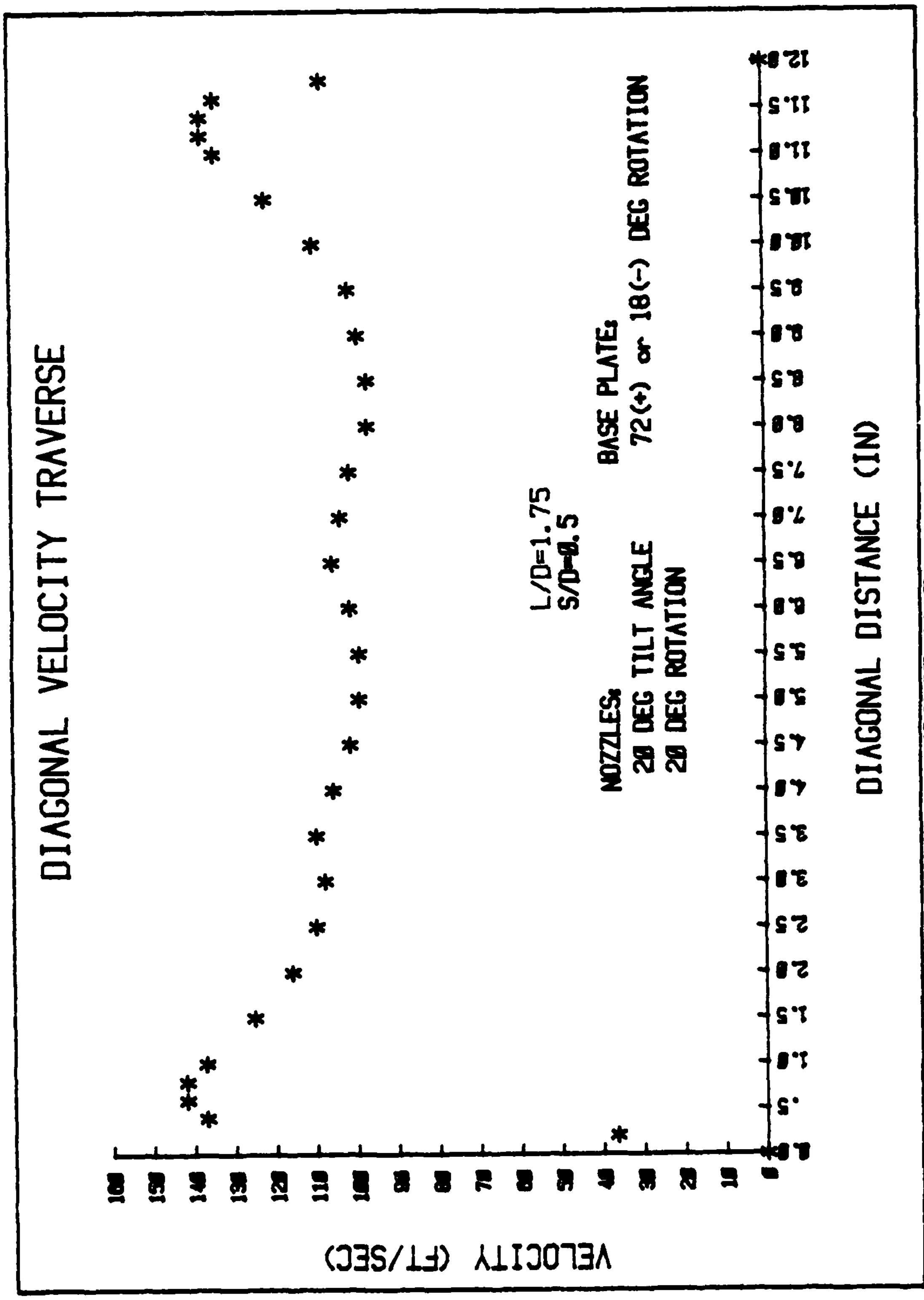

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
L/D=1.75
S/D=0.5
NOZZLES
20 DEG TILT ANGLE
20 DEG ROTATION
BASE PLATE:
72(+) or 18(-) DEG ROTATION

FIGURE 41.4



DIAGONAL VELOCITY TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION
BASE PLATE:
72(+) or 18(-) DEG ROTATION
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)

FIGURE 41.5

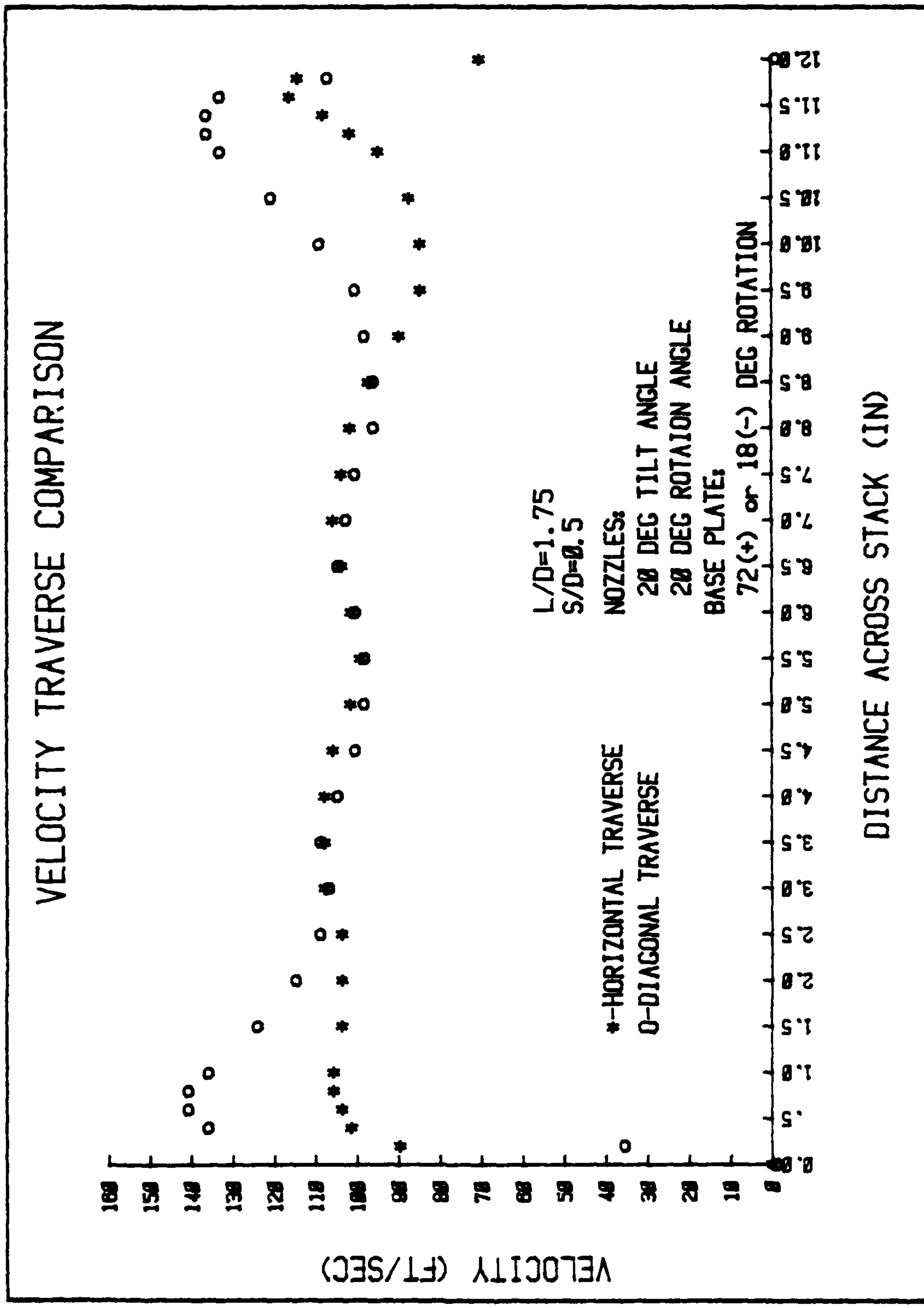

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.75
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTAION ANGLE
BASE PLATE:
72(+) or 18(-) DEG ROTATION
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0

FIGURE 41.8

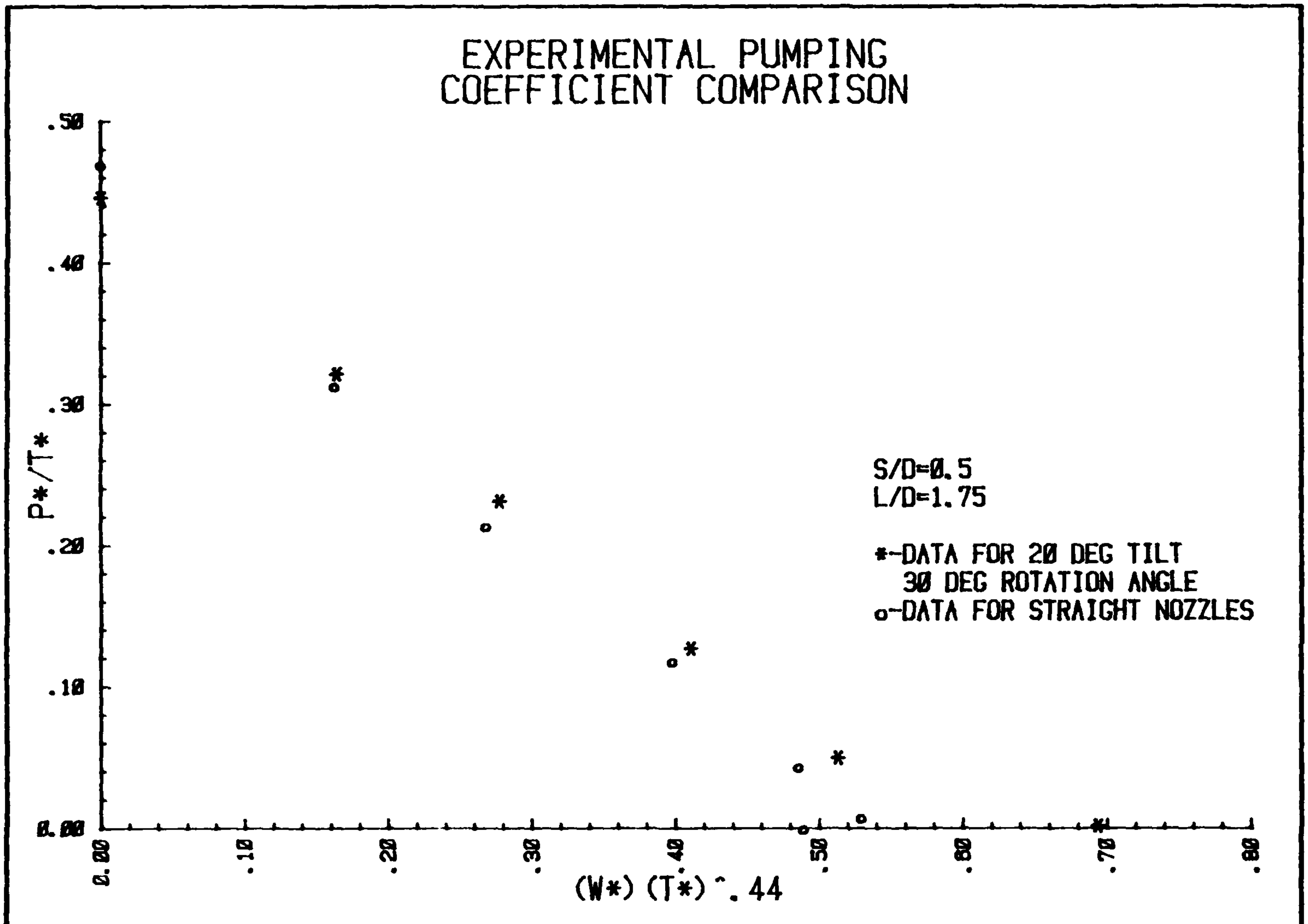

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*) ^.44
S/D=0.5
L/D=1.75
*-DATA FOR 20 DEG TILT
30 DEG ROTATION ANGLE
o-DATA FOR STRAIGHT NOZZLES
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 42

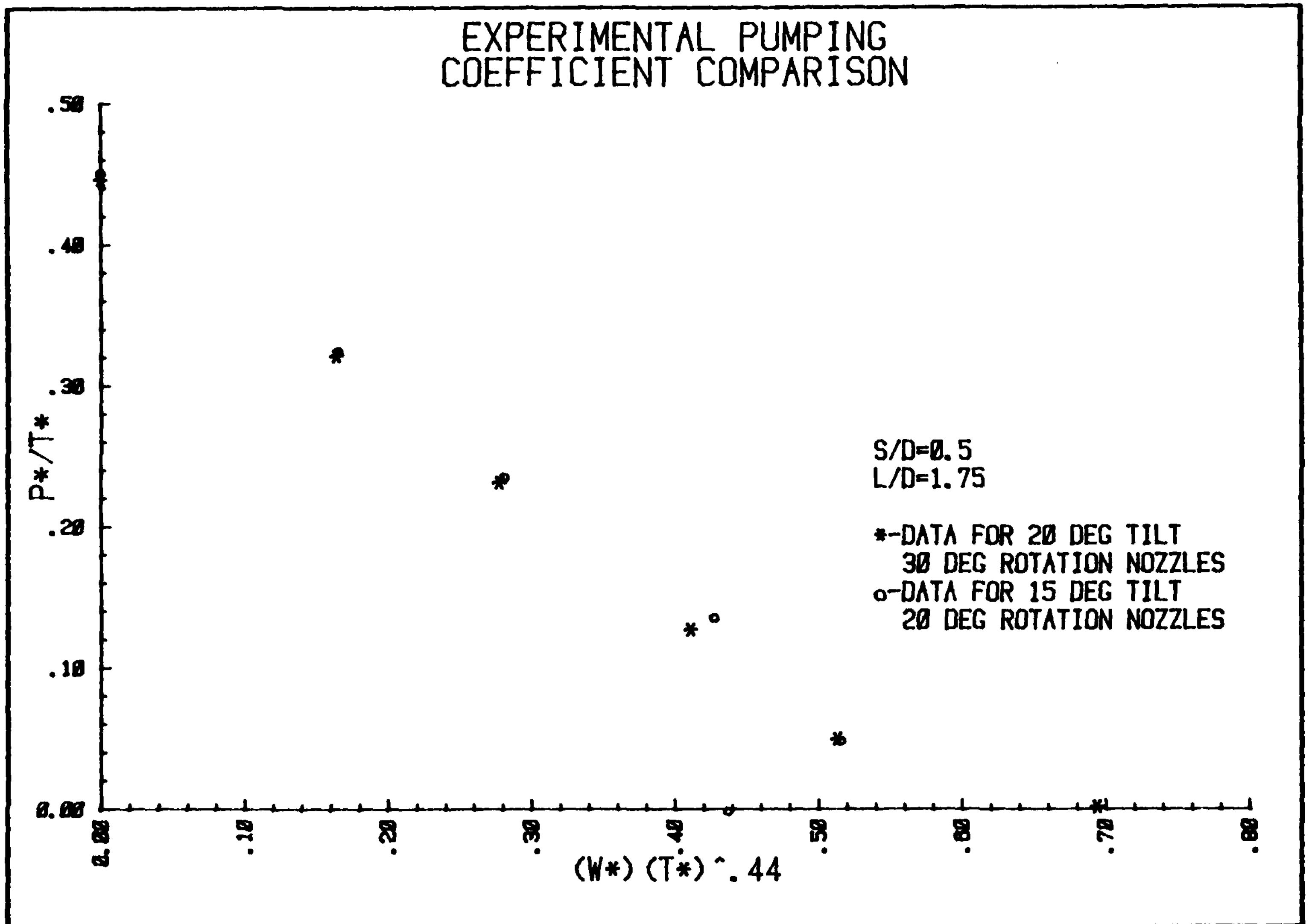

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
.50
.40
.30
.20
.10
0.00
P*/T*
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.75
*-DATA FOR 20 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 42.1

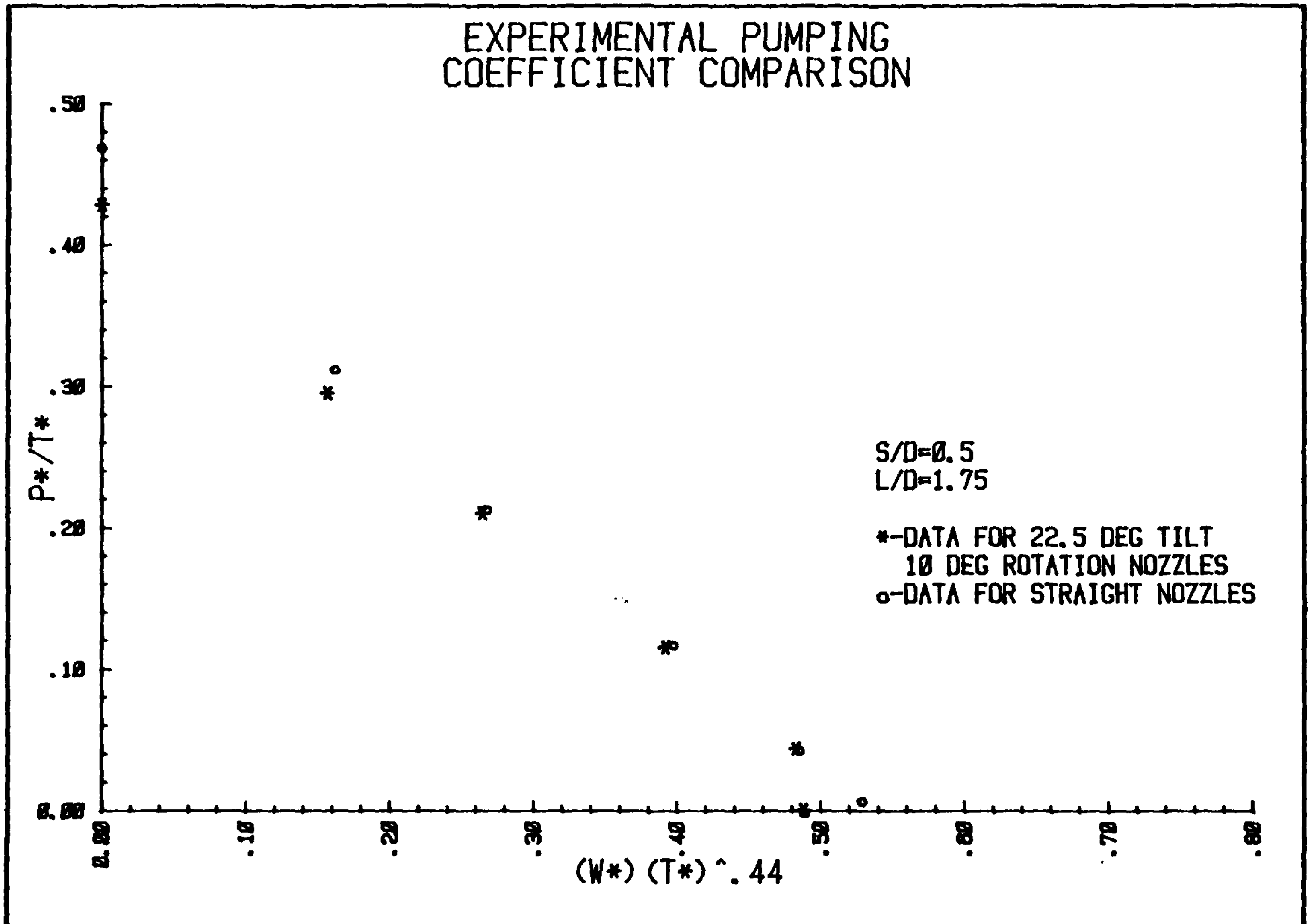

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 43

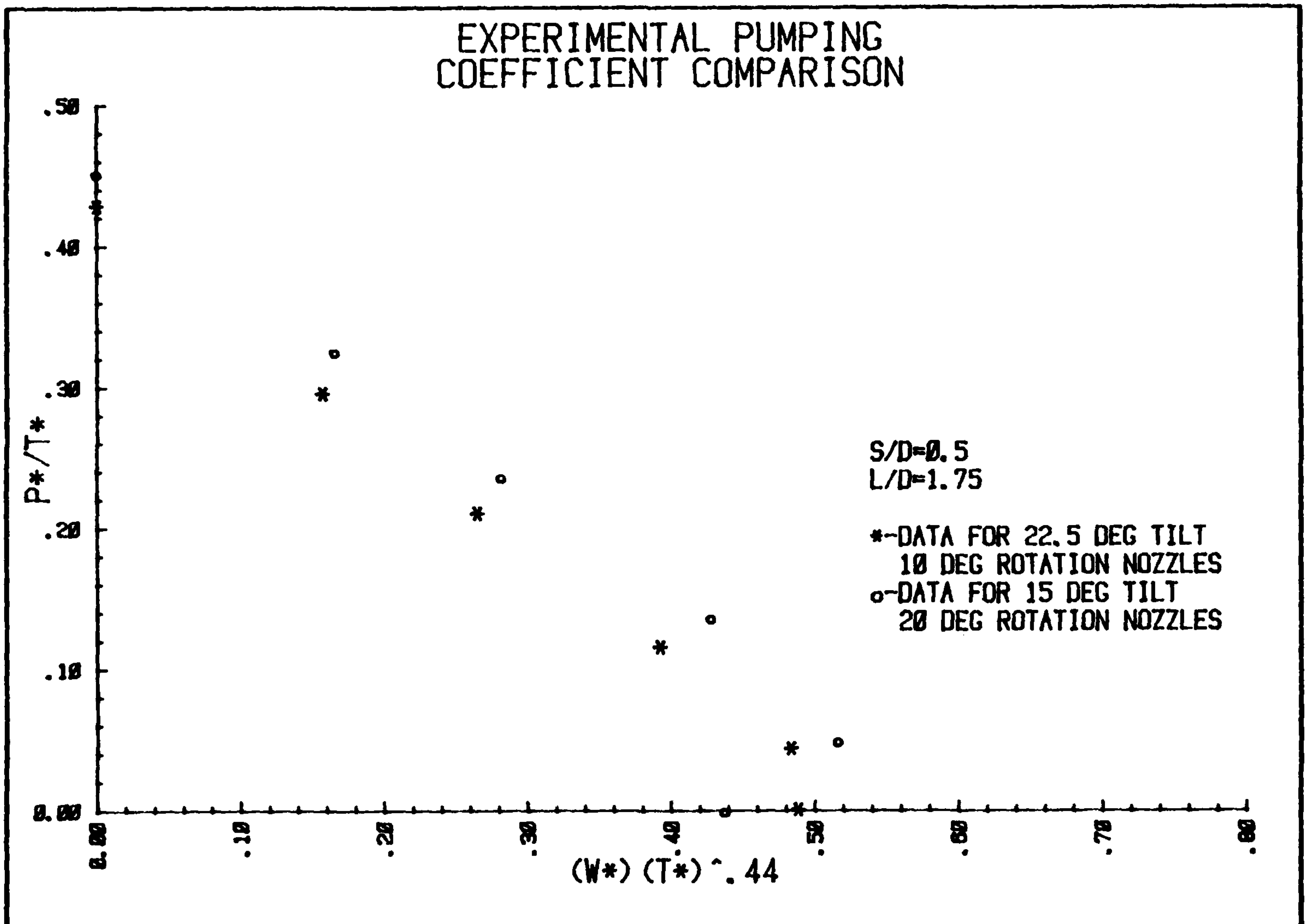

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 43.1

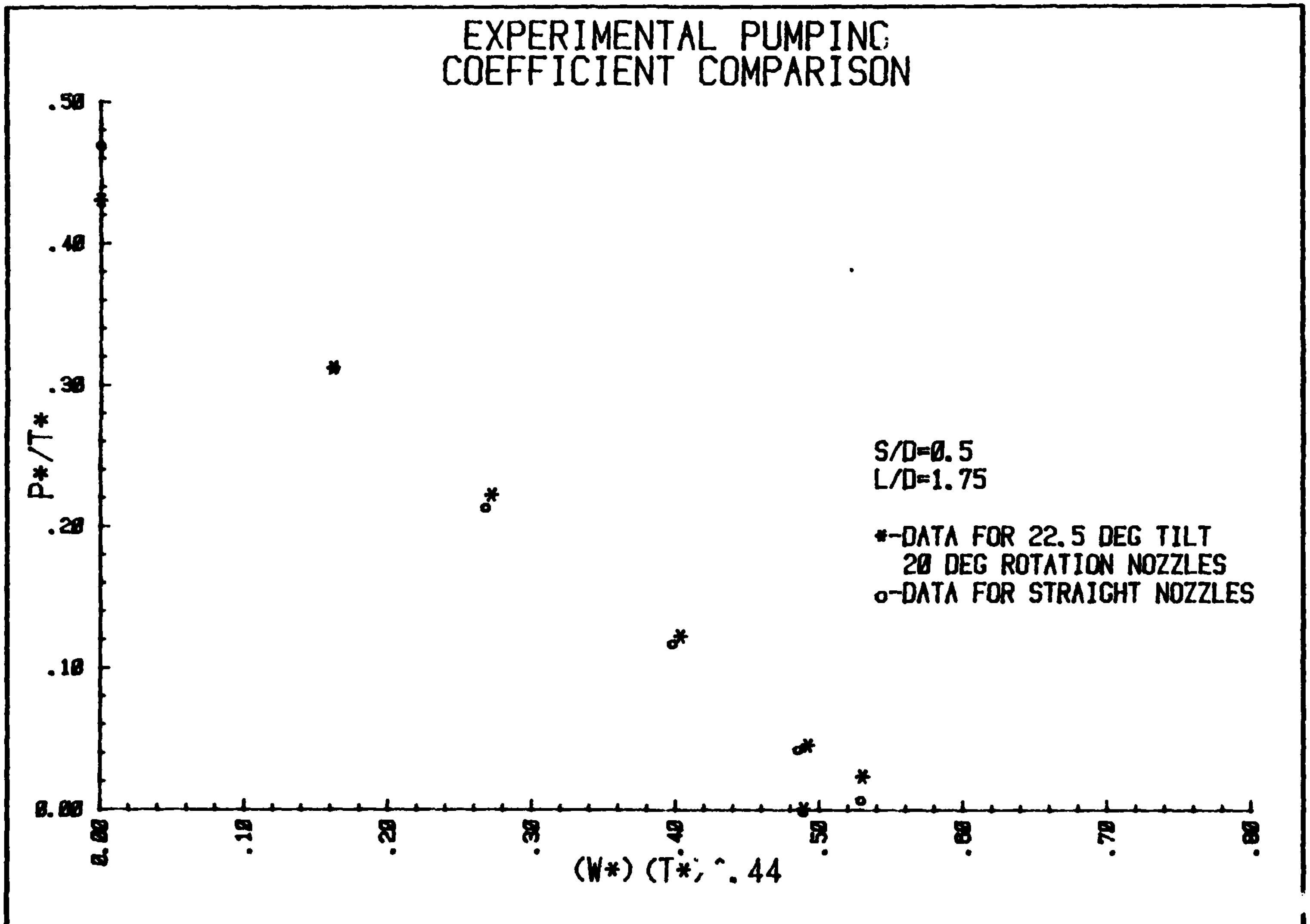

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*) ^ .44
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 44

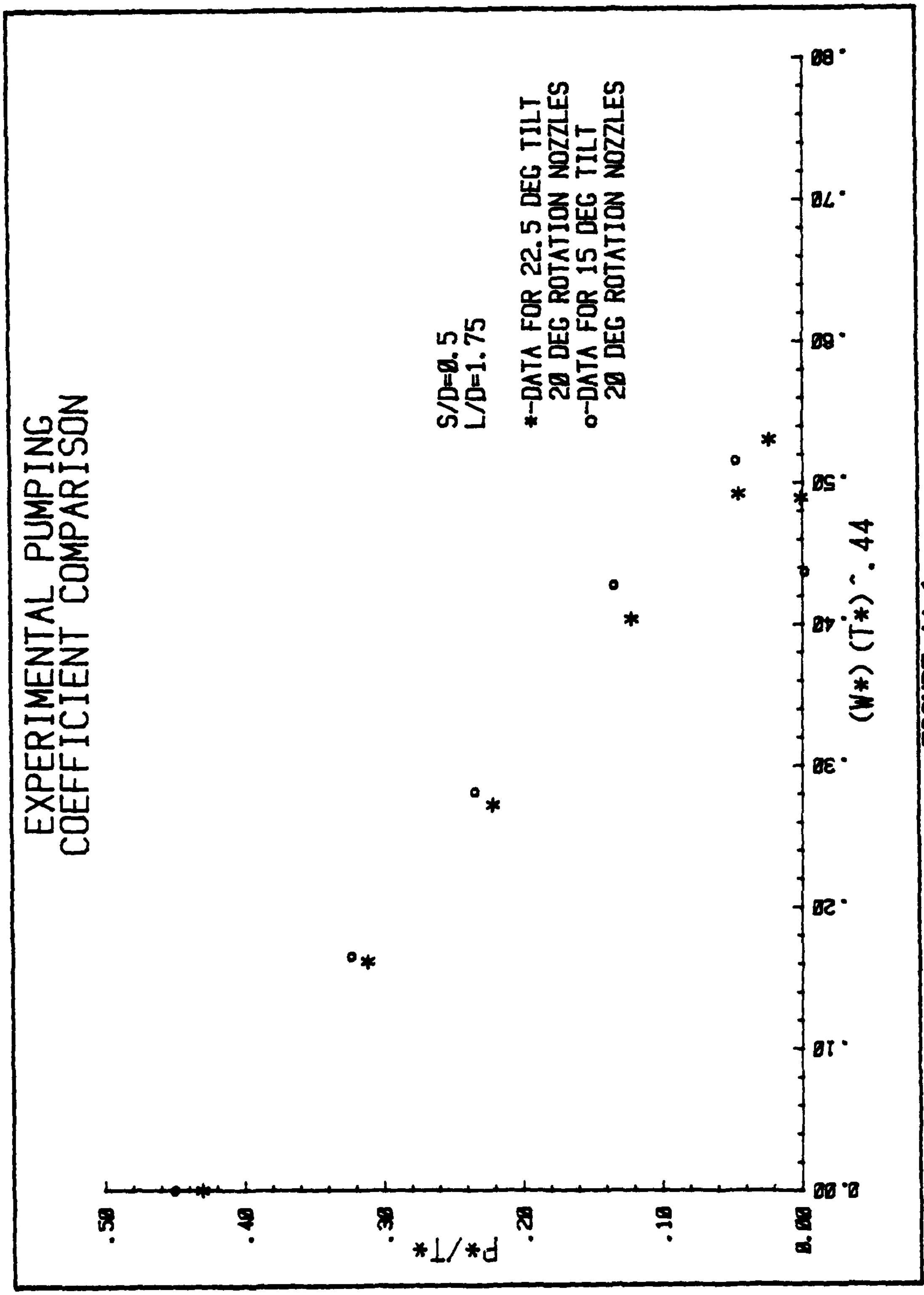

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44

FIGURE 44.1

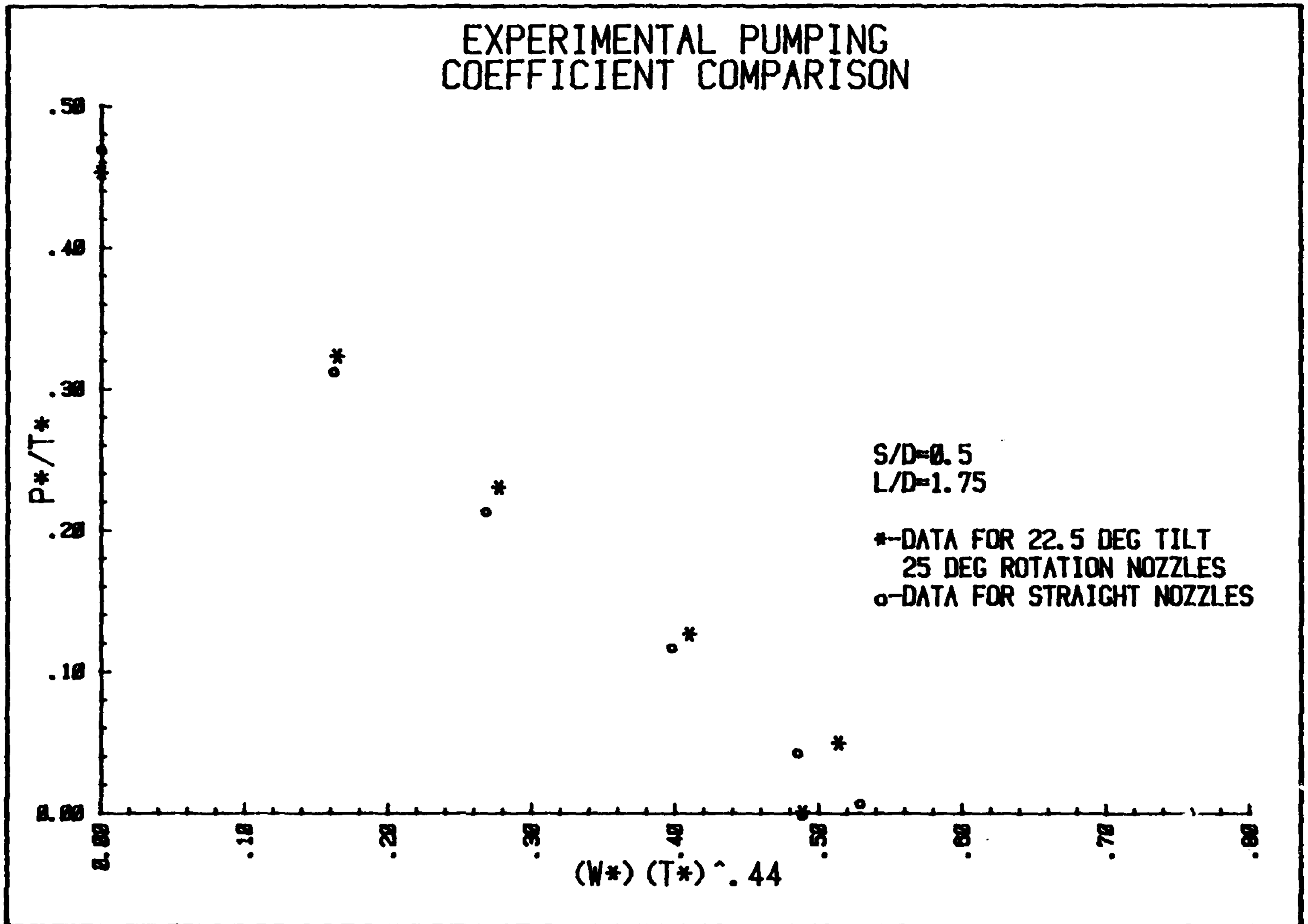
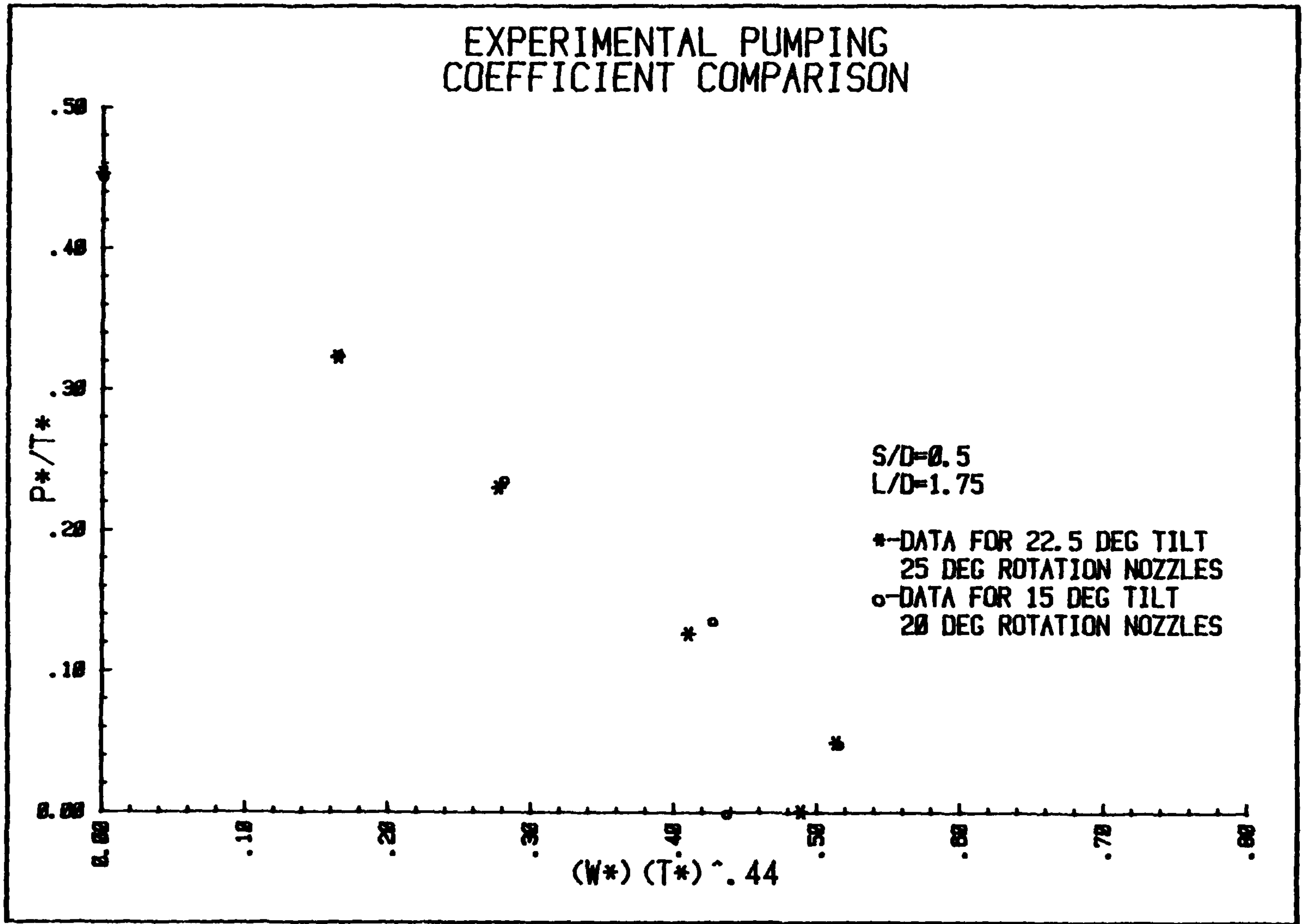

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
25 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 45



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.75
*-DATA FOR 22.5 DEG TILT
25 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 45.1

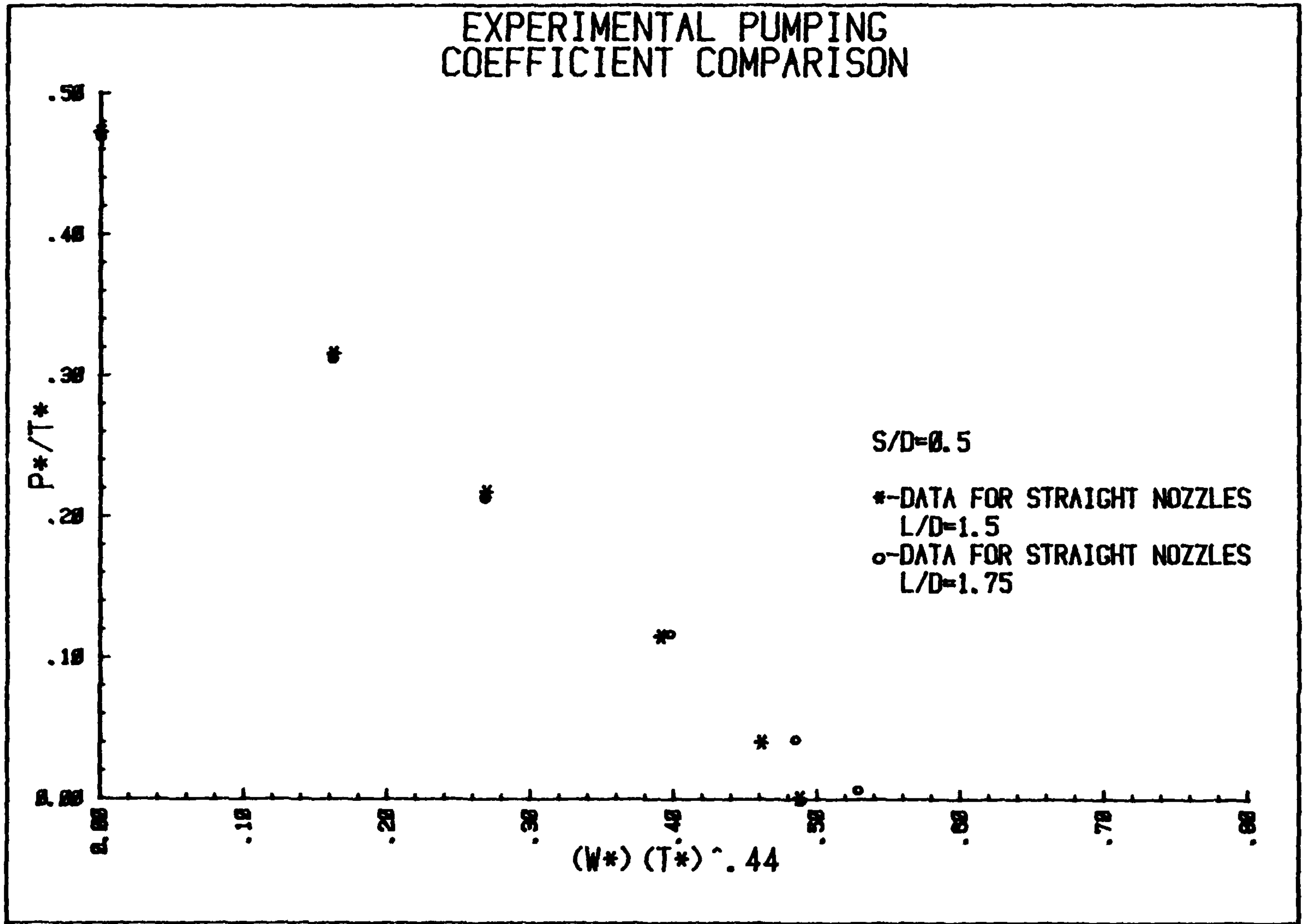

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
*-DATA FOR STRAIGHT NOZZLES
L/D=1.5
o-DATA FOR STRAIGHT NOZZLES
L/D=1.75
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 46

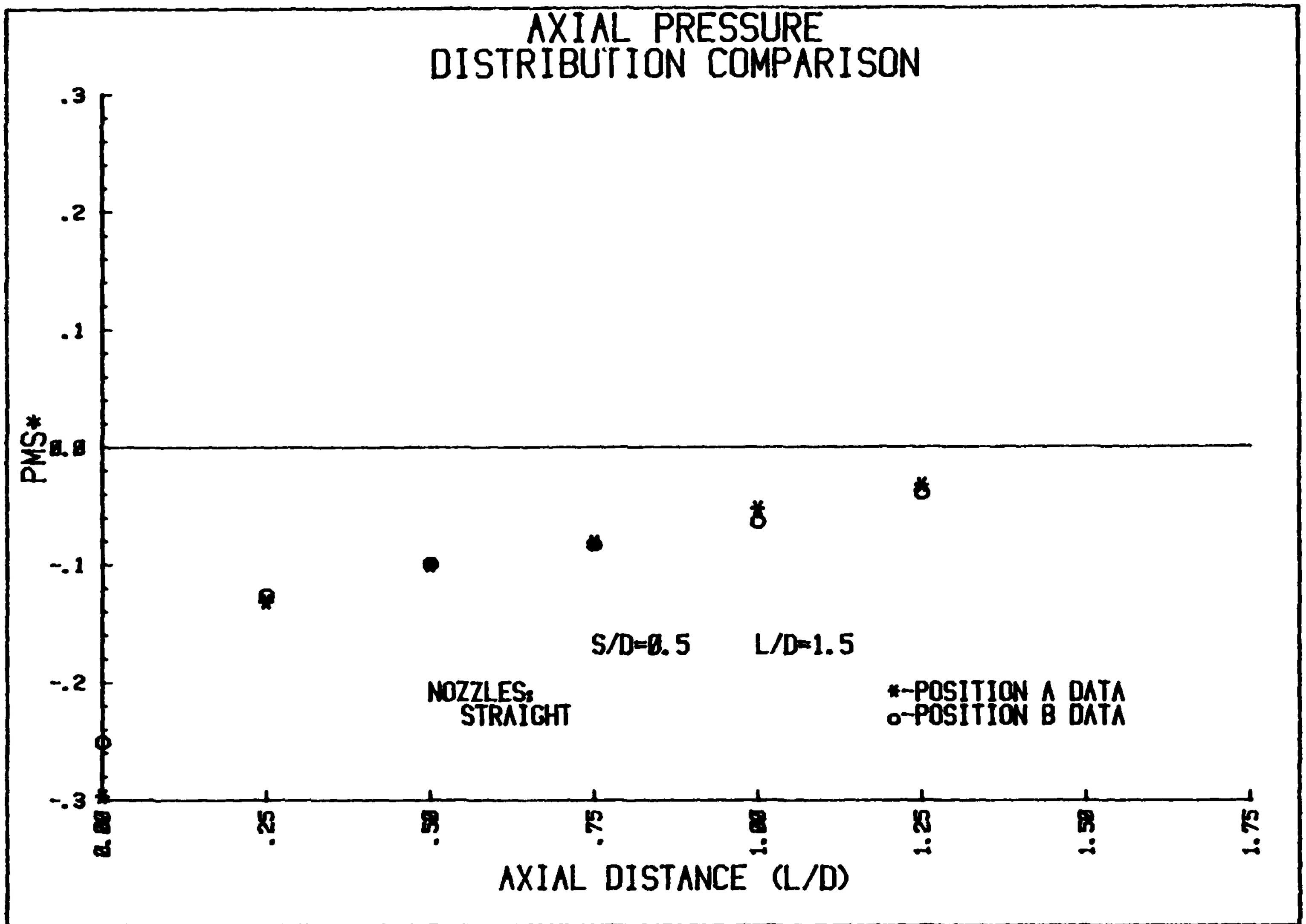

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
S/D=0.5
L/D=1.5
NOZZLES:
STRAIGHT
*-POSITION A DATA
o-POSITION B DATA

FIGURE 46.1

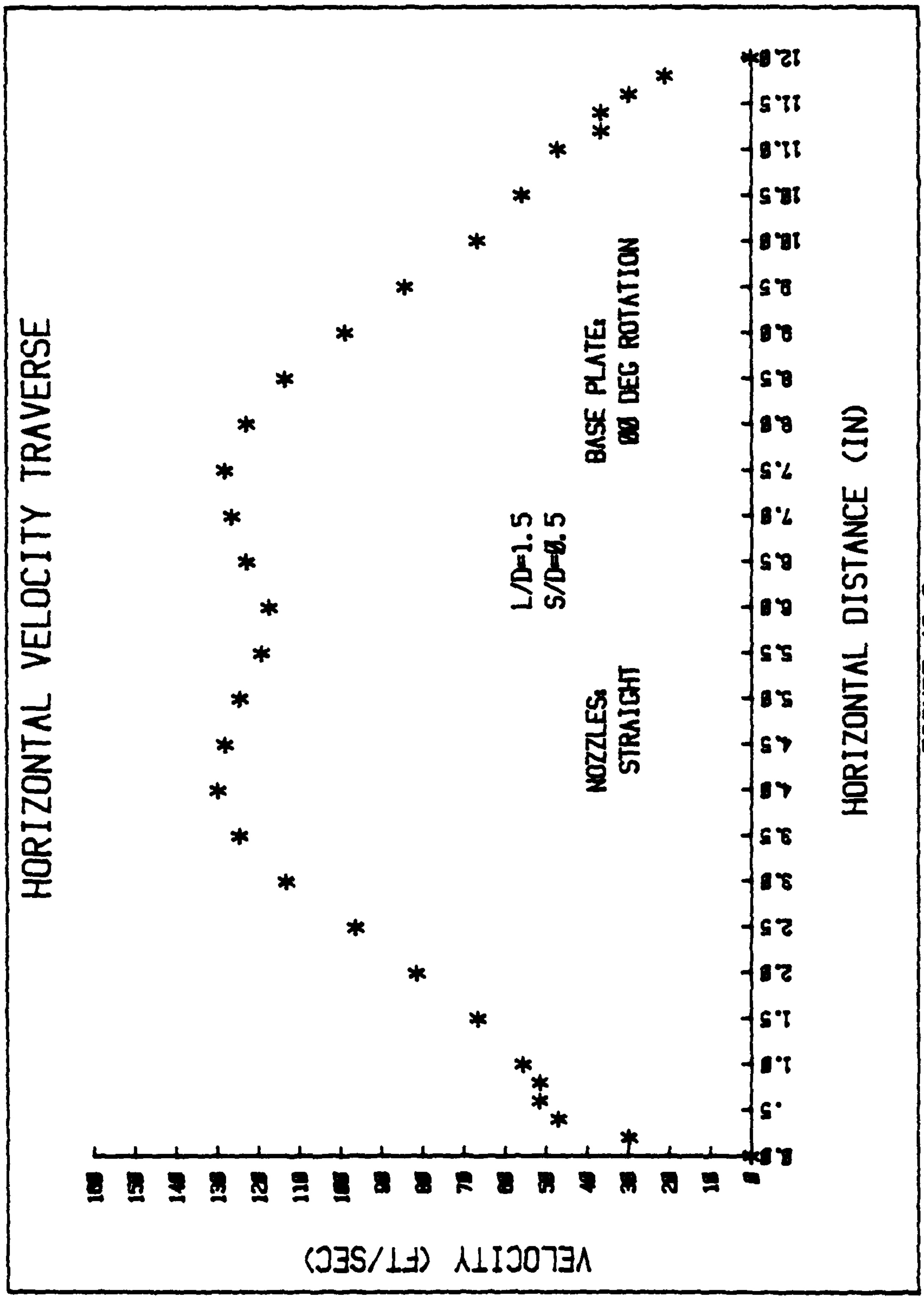
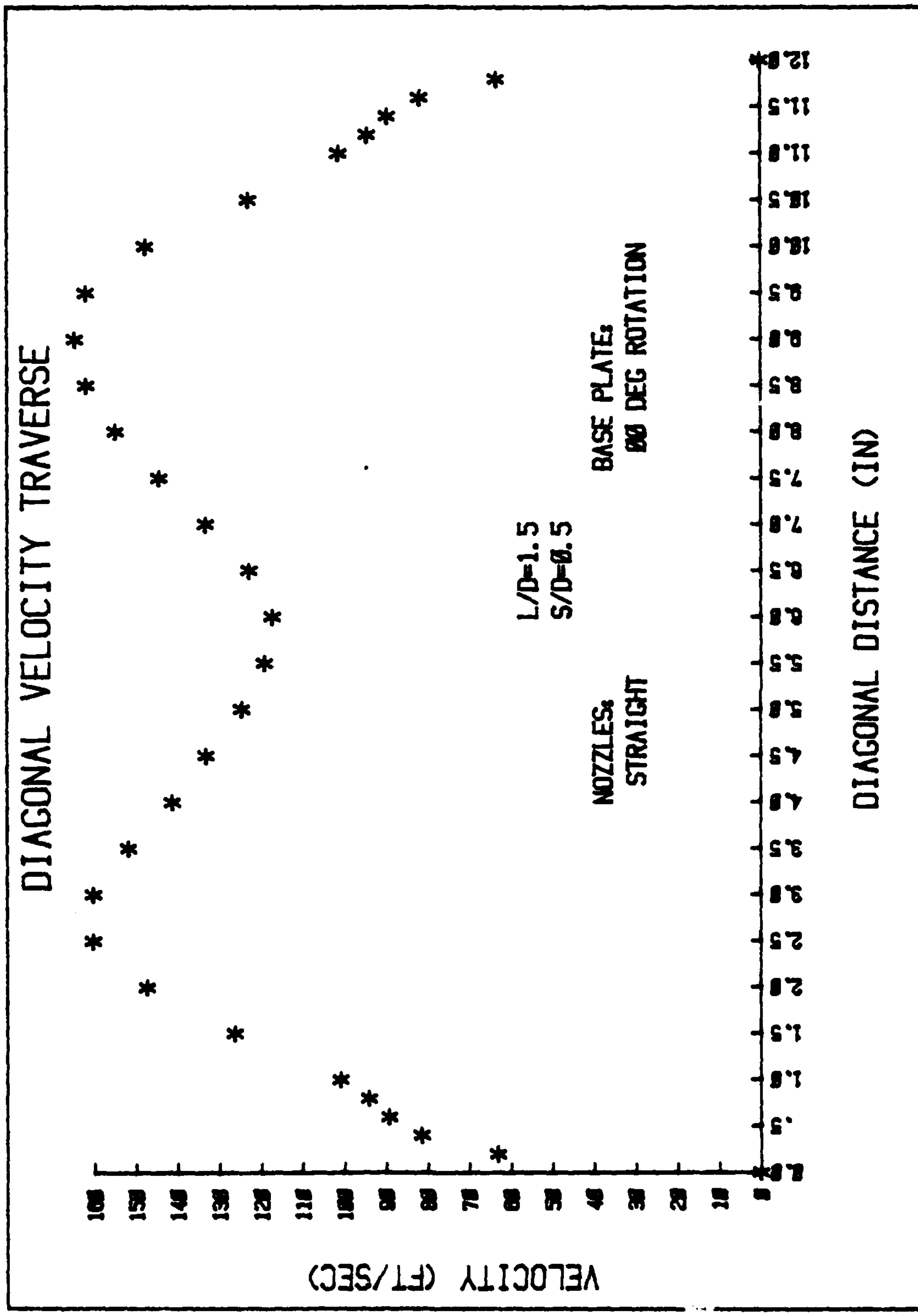

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
NOZZLES: STRAIGHT
L/D=1.5
S/D=0.5
BASE PLATE: 00 DEG ROTATION

FIGURE 4B.2



DIAGONAL VELOCITY TRAVERSE
L/D=1.5
S/D=Ø.5
NOZZLES:
STRAIGHT
BASE PLATE:
ØØ DEG ROTATION
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)

FIGURE 4B.3

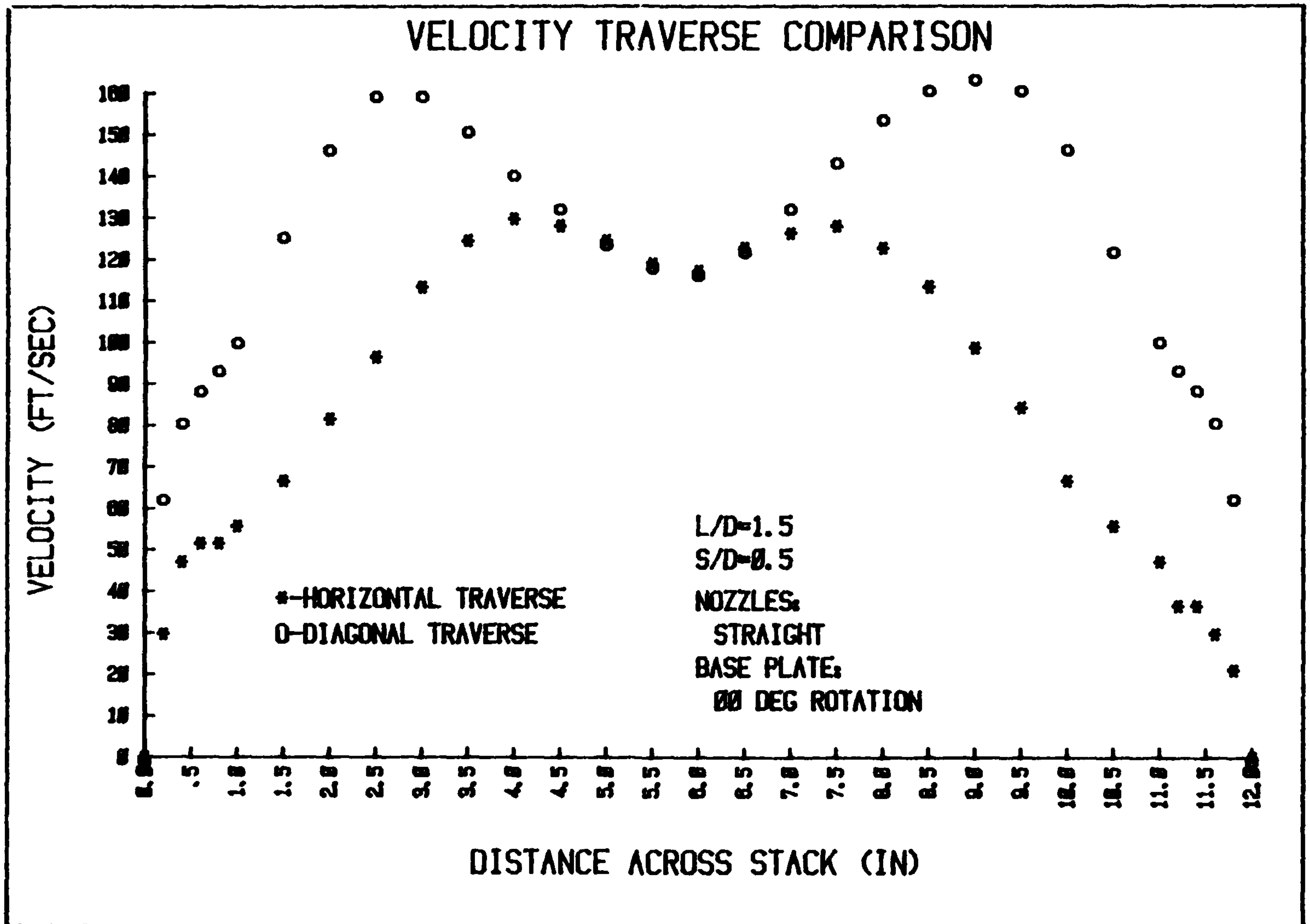

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.5
S/D=0.5
NOZZLES:
STRAIGHT
BASE PLATE:
00 DEG ROTATION
0.0
.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
DISTANCE ACROSS STACK (IN)

FIGURE 46.4

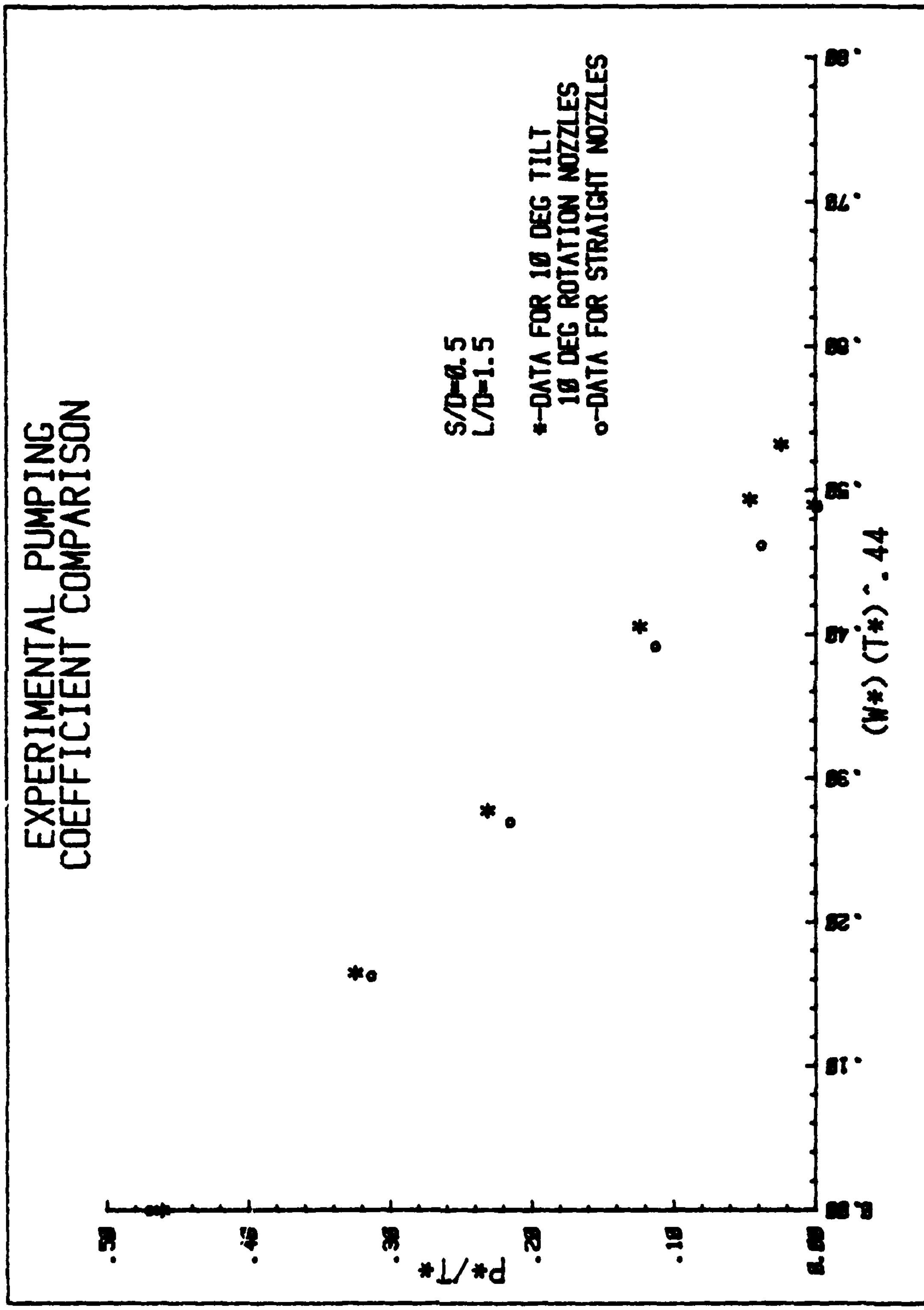

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 47

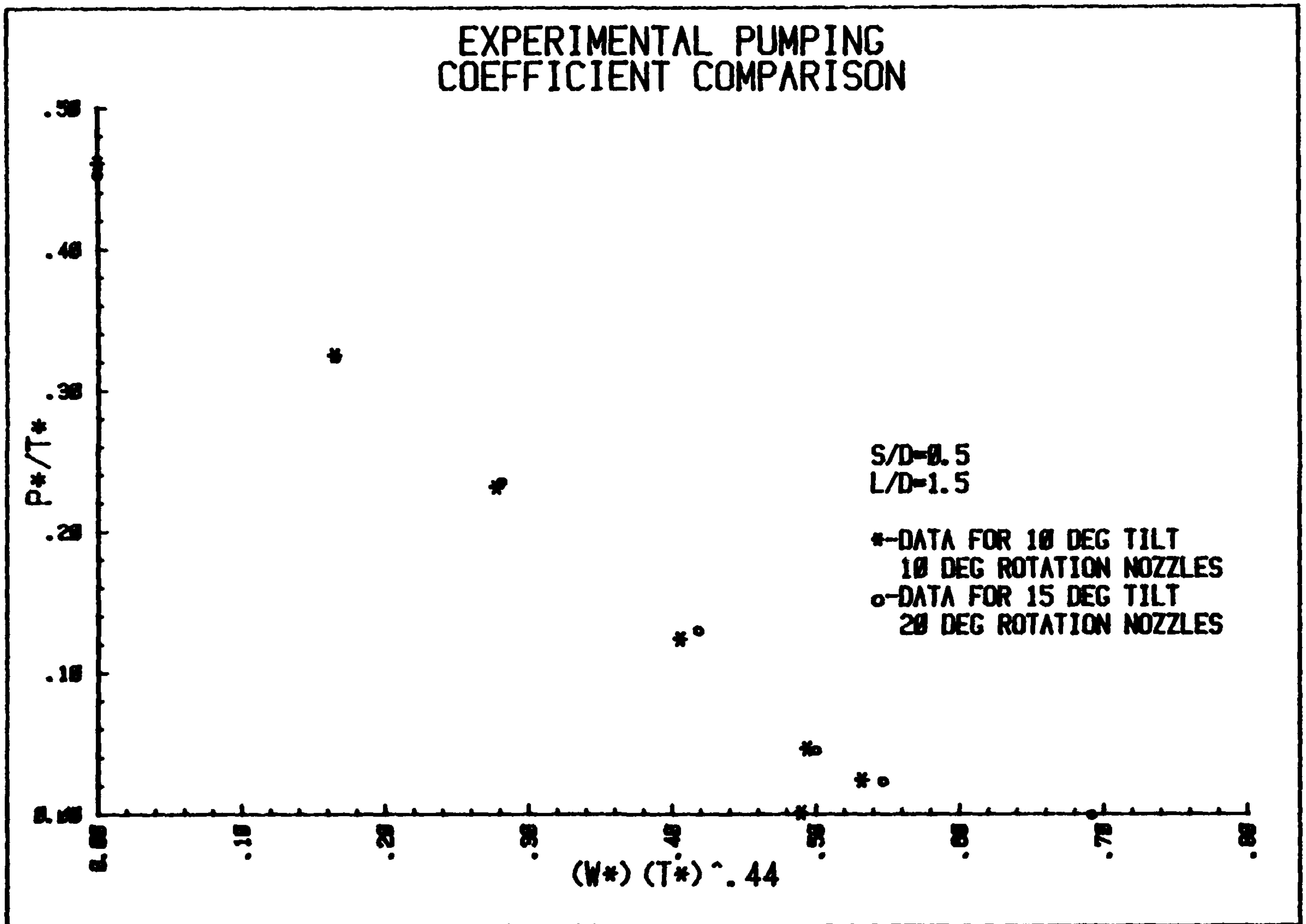

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
.50
.40
.30
.20
.10
0.00
P*/T*
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 47.1

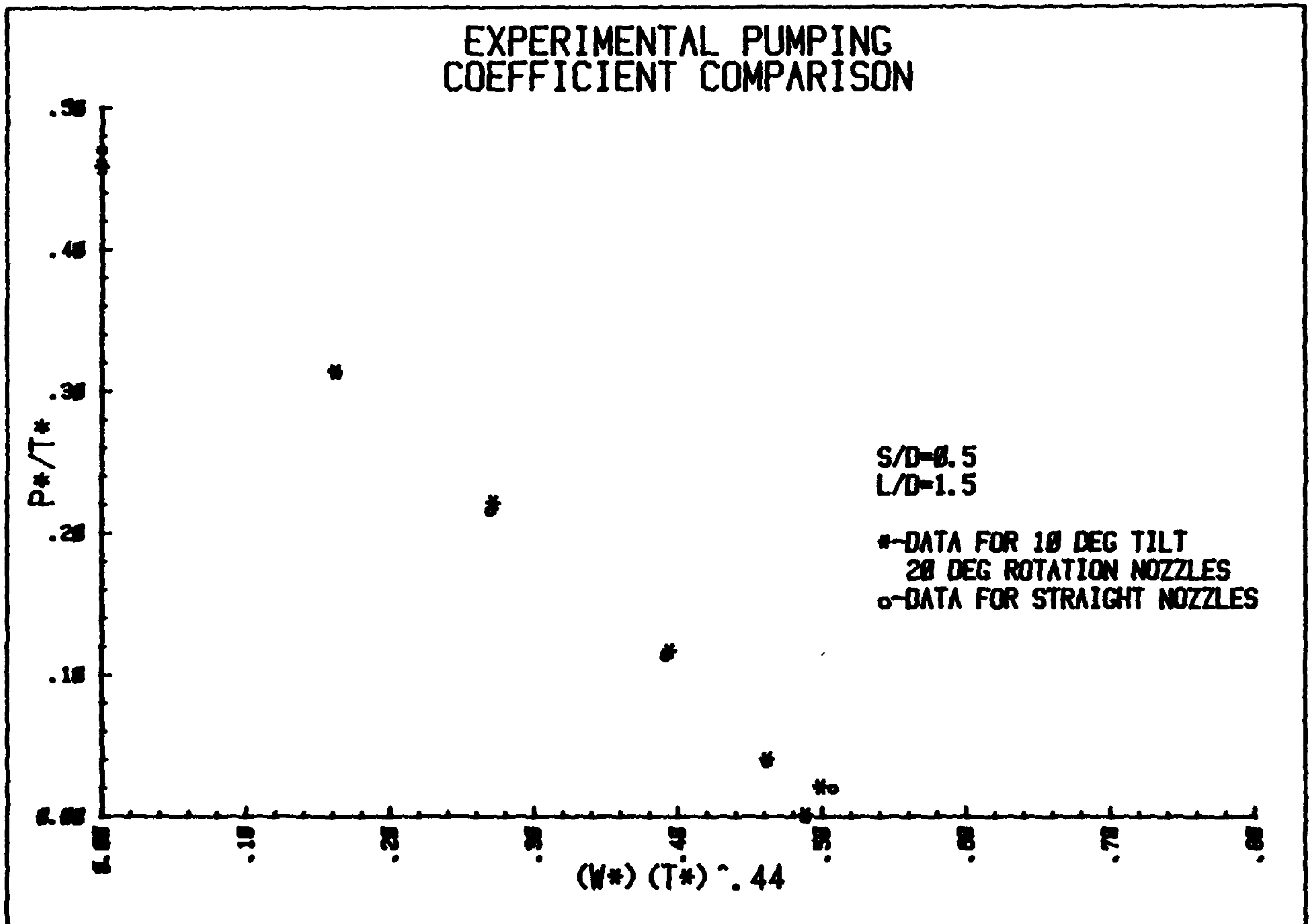
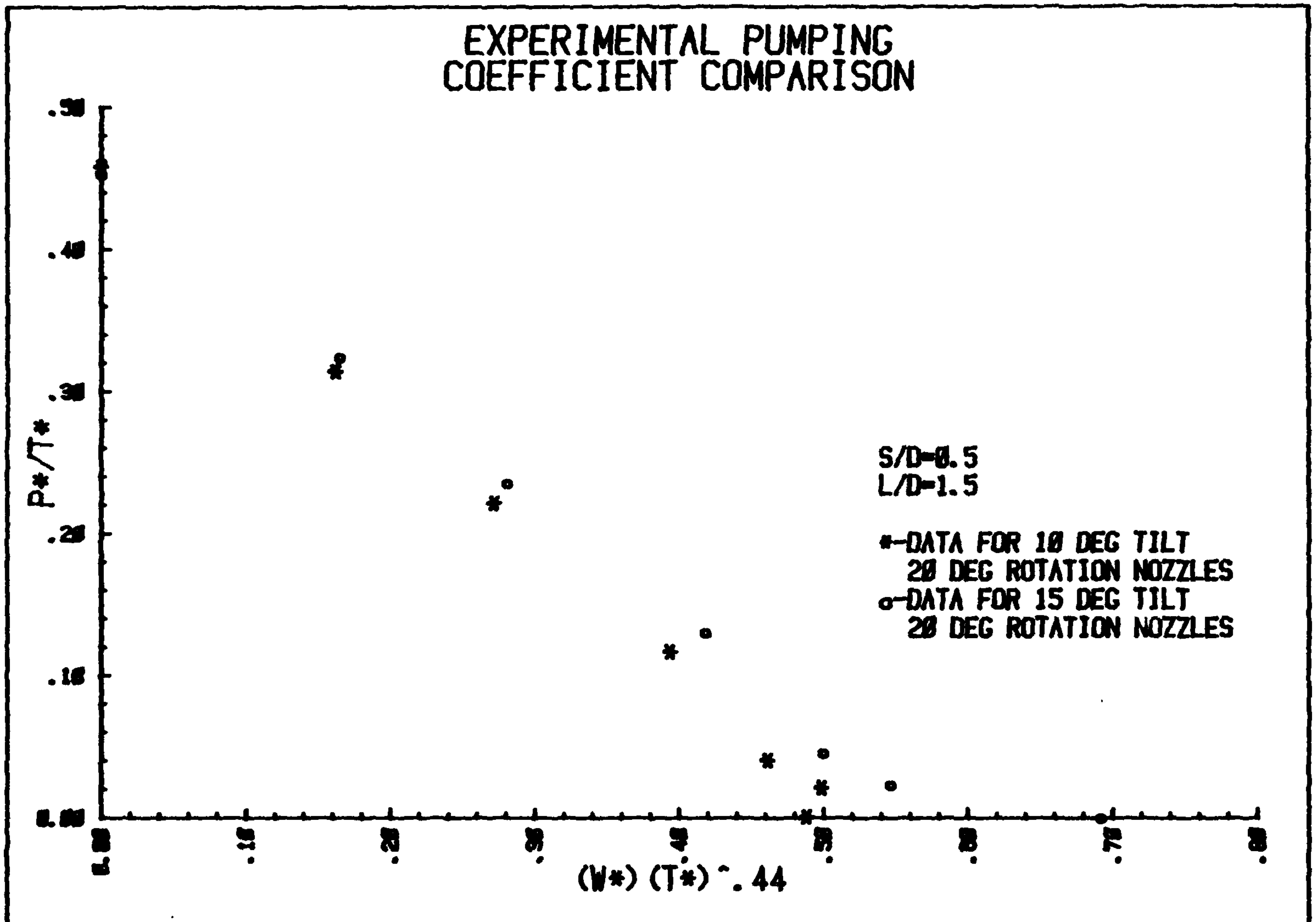

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 48



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44

FIGURE 4B.1

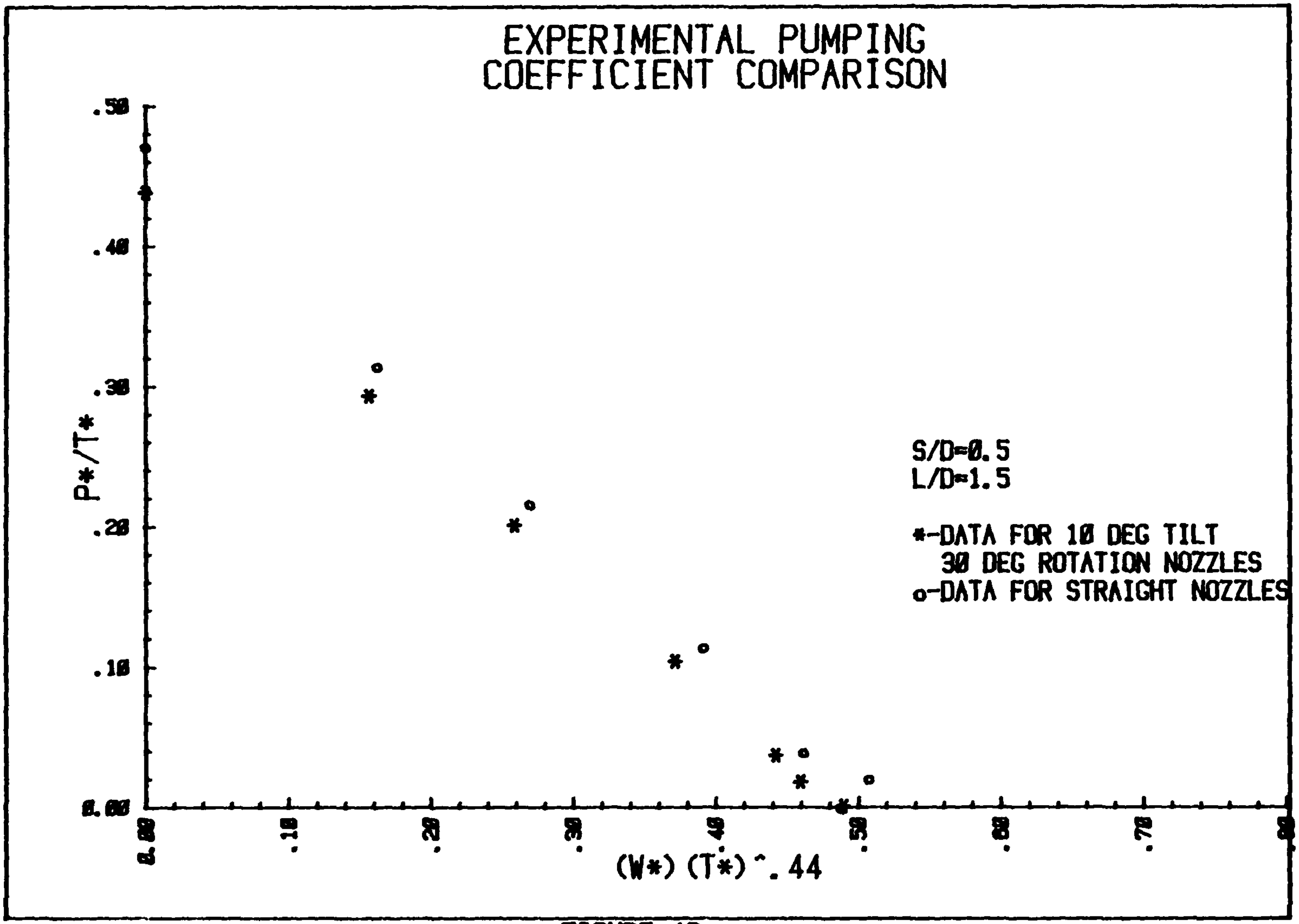

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 49

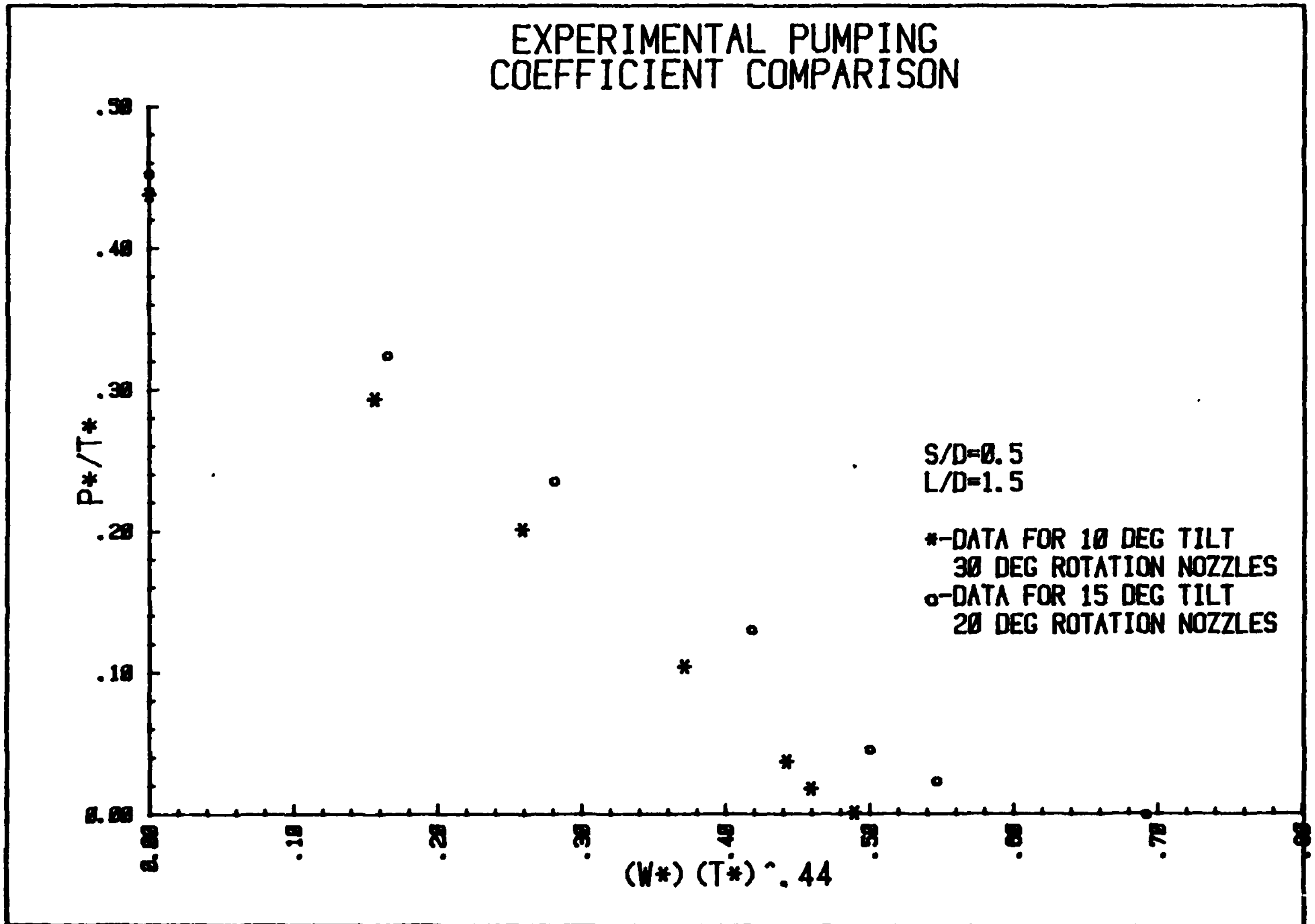

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 49.1

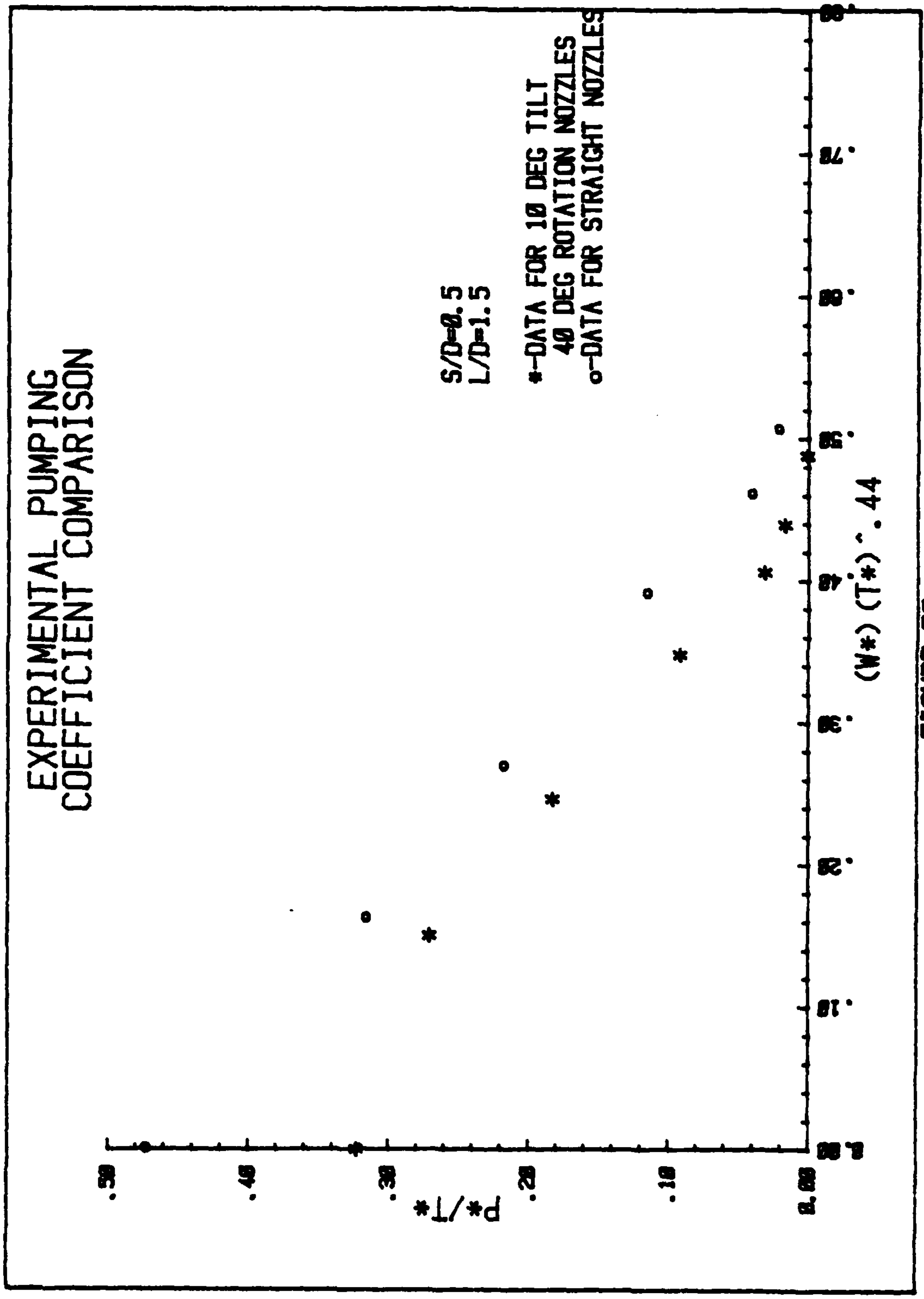

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 50

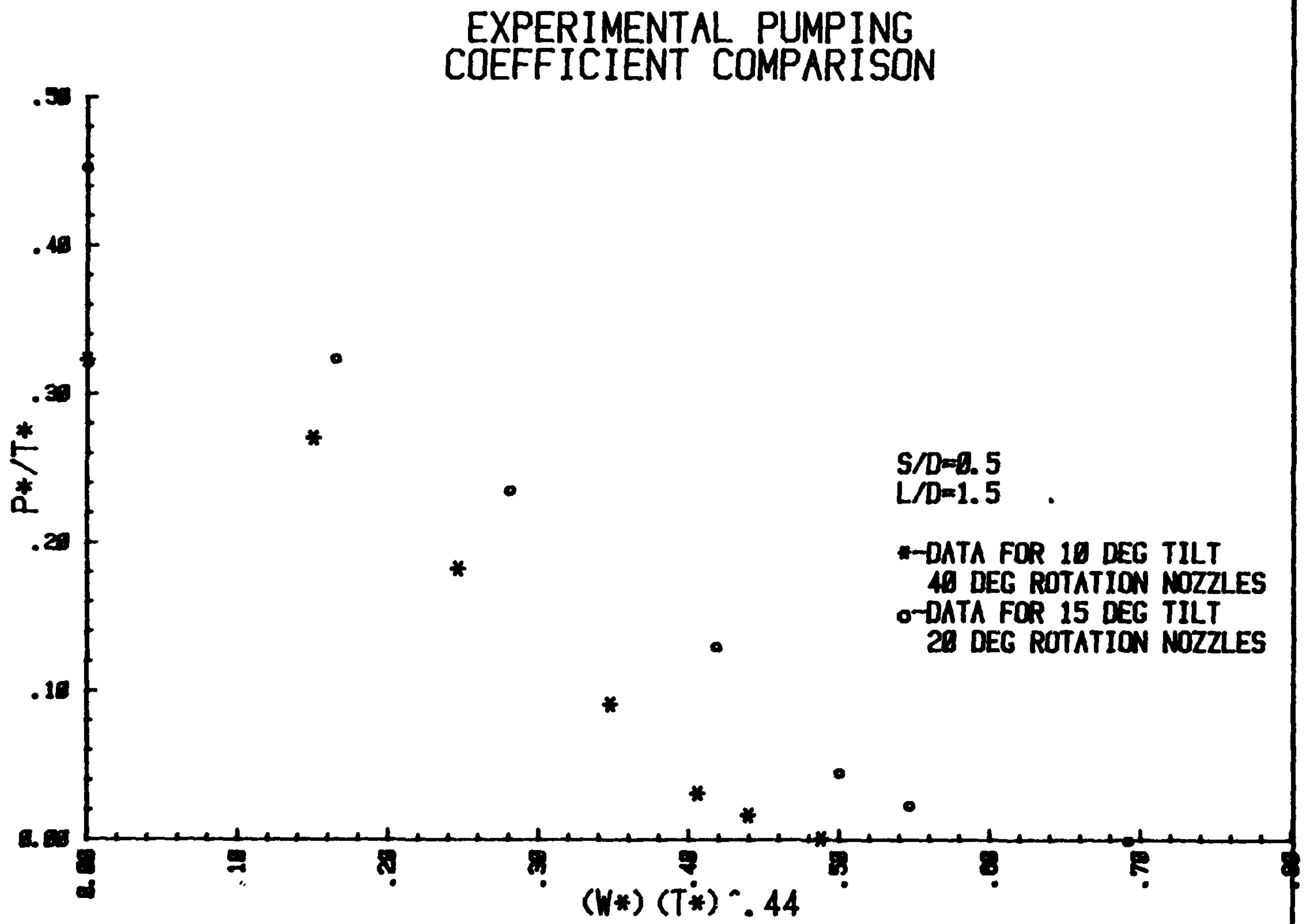

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.5
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 50.1

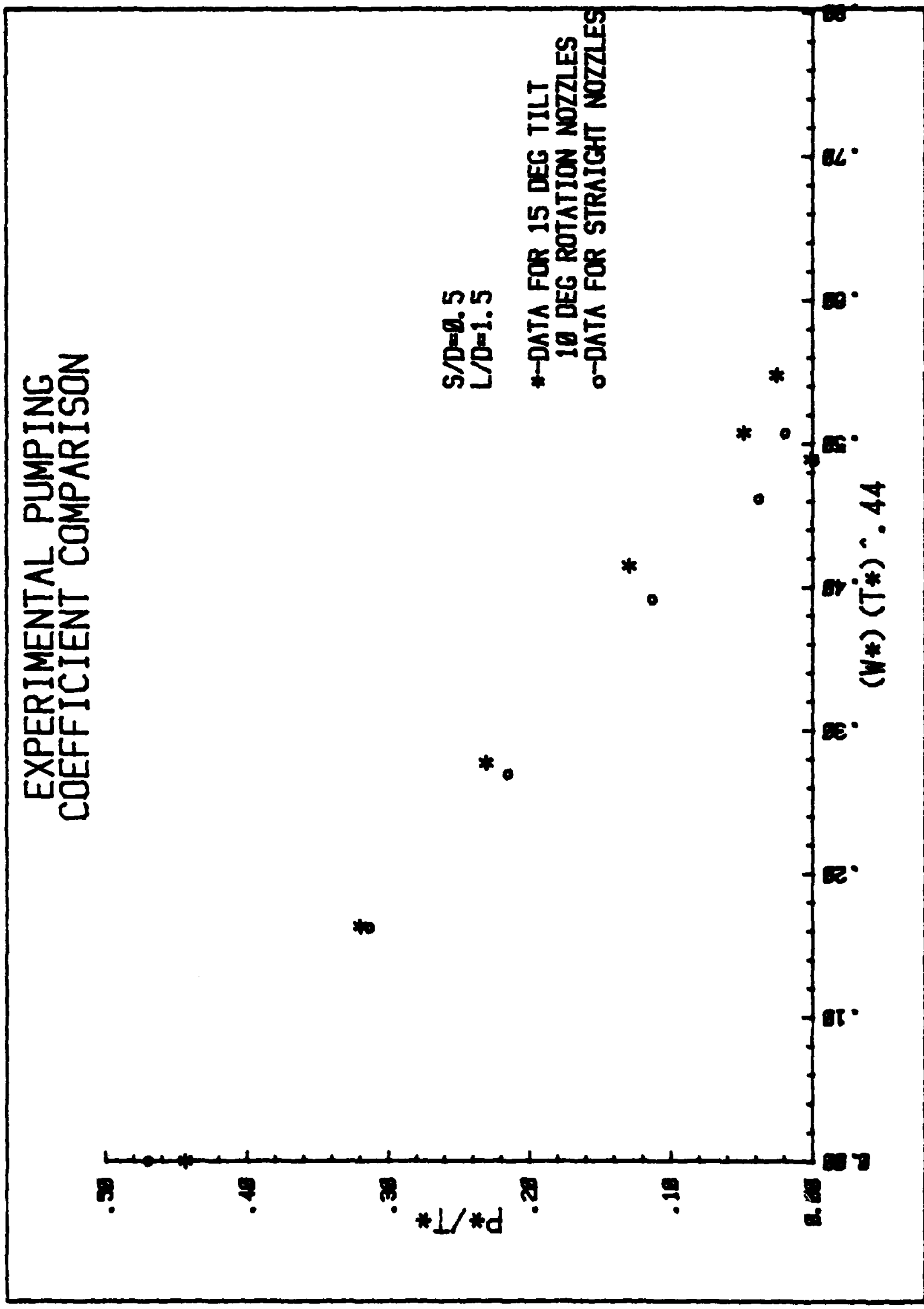

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 51

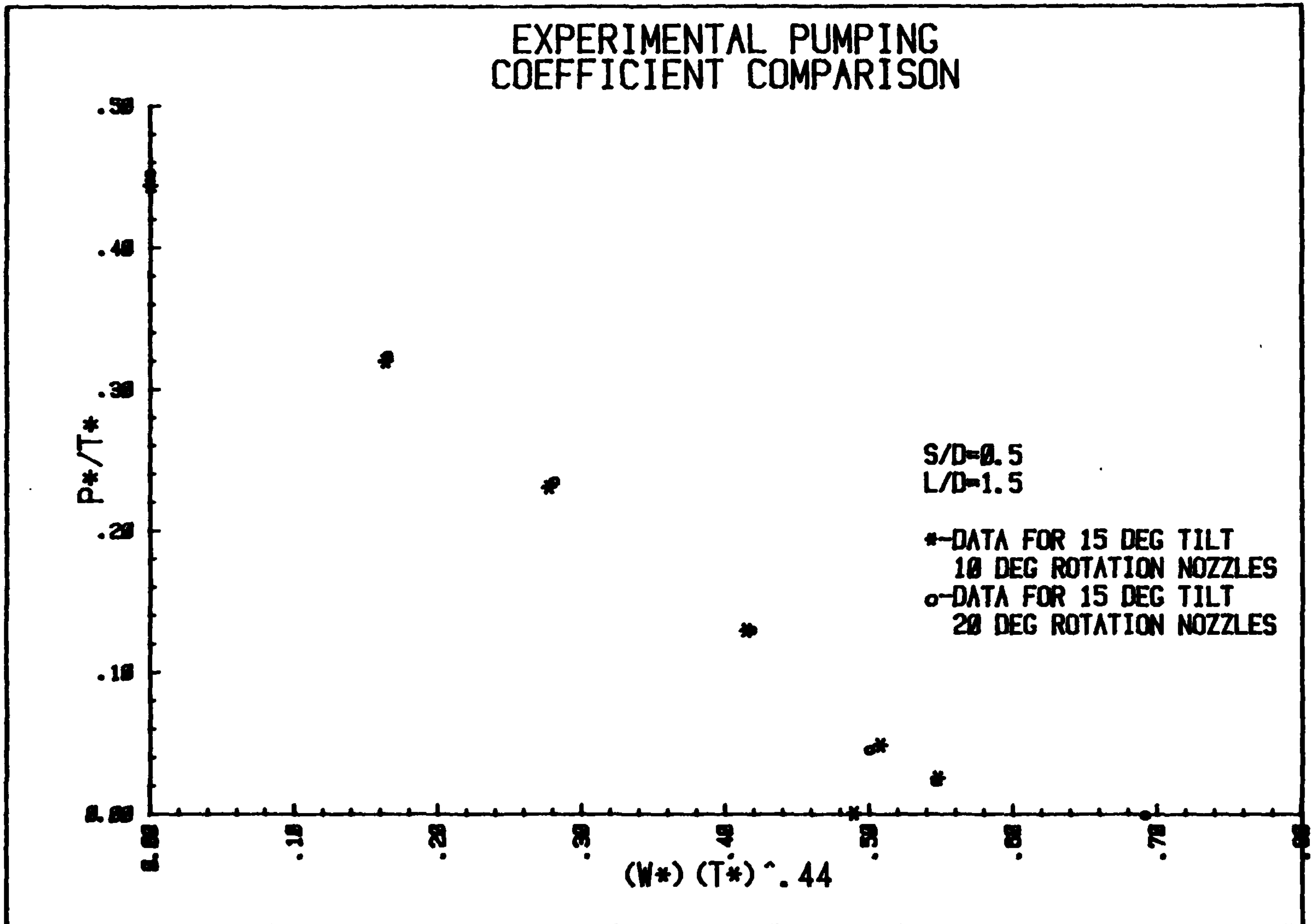

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 51.1

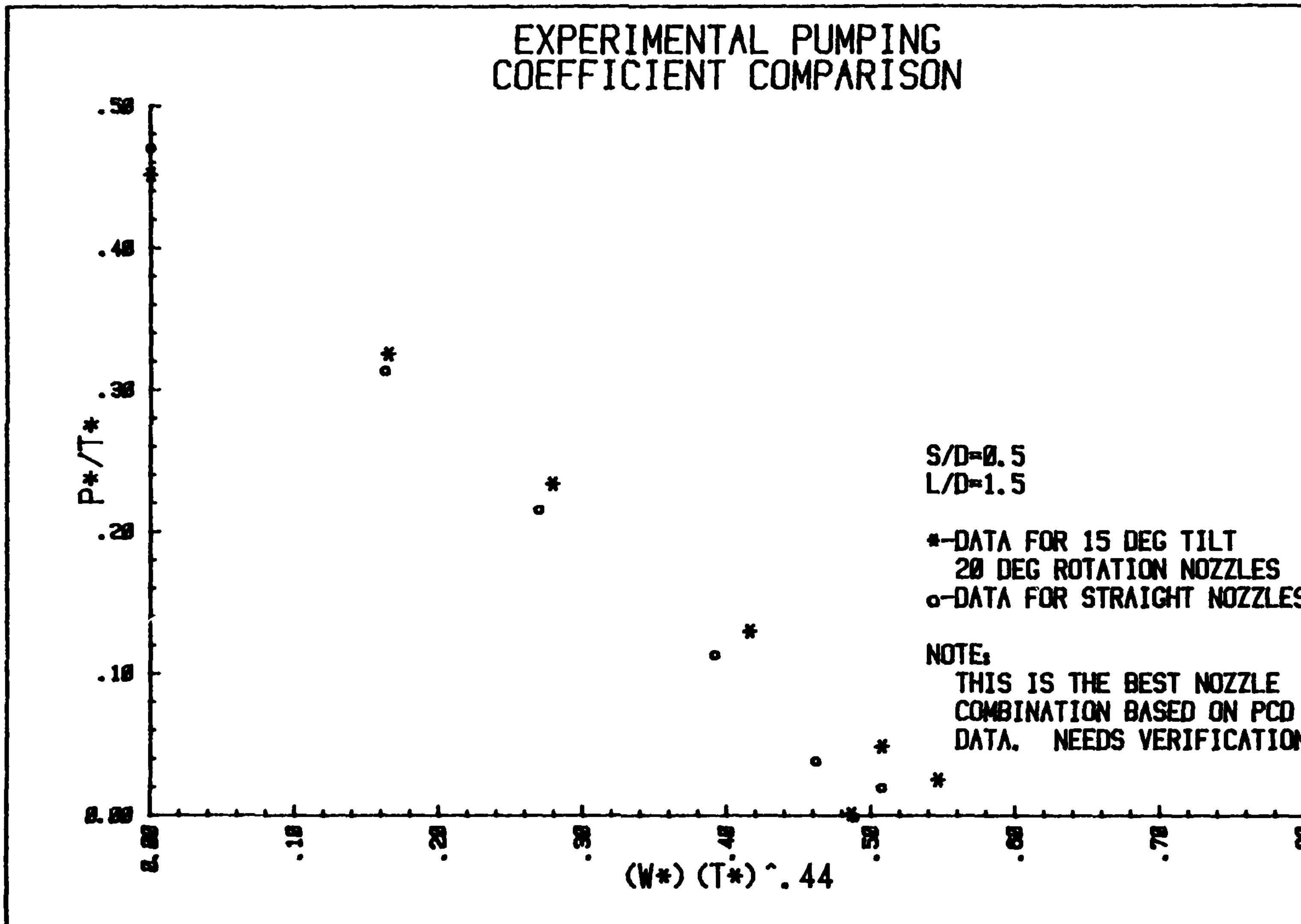

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
NOTE:
THIS IS THE BEST NOZZLE
COMBINATION BASED ON PCD
DATA. NEEDS VERIFICATION.

FIGURE 52

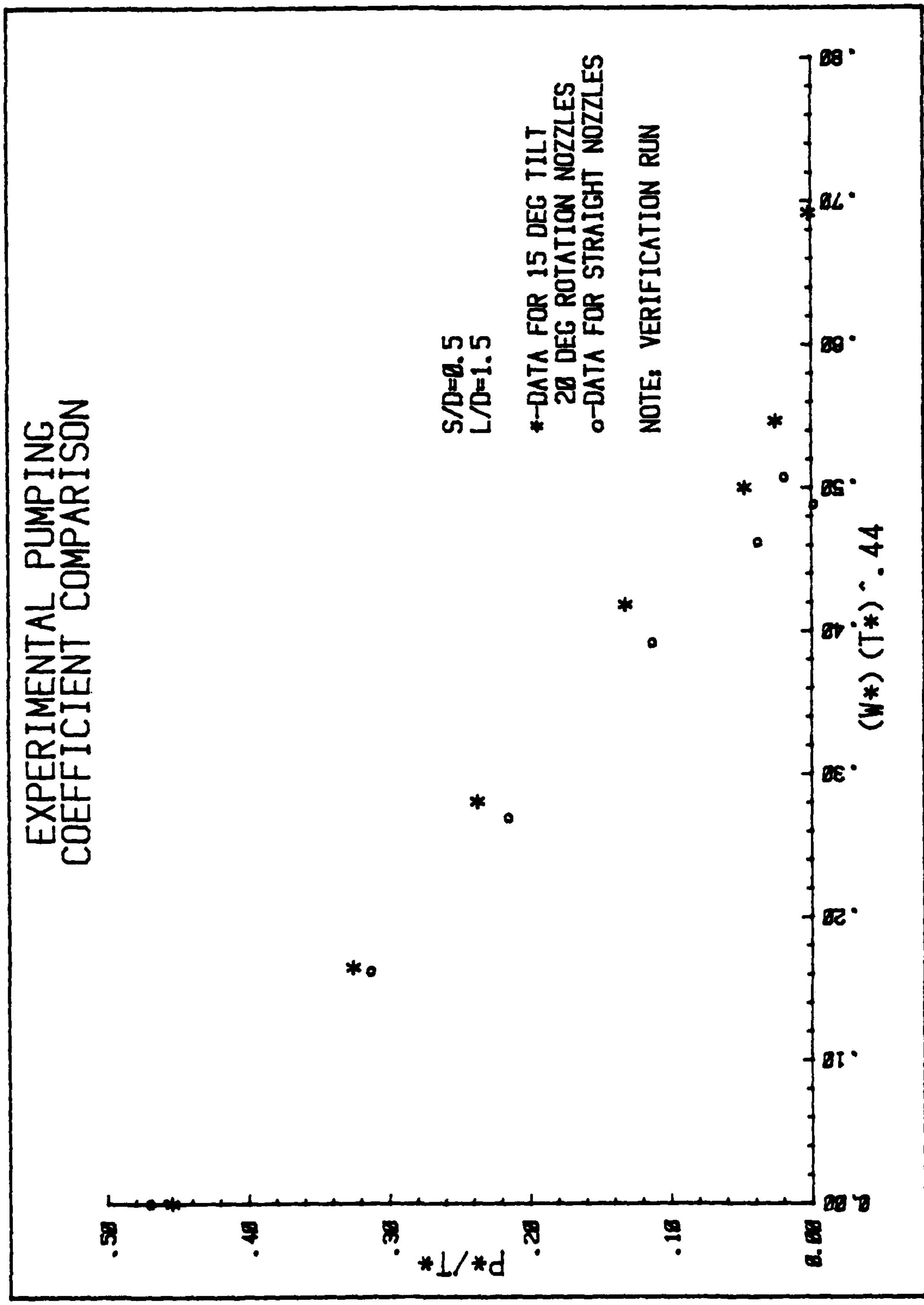

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=Ø.5
L/D=1.5
*-DATA FOR 15 DEG TILT
2Ø DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
NOTE; VERIFICATION RUN
P*/T*
(W*)(T*)^.44
Ø.ØØ
.1Ø
.2Ø
.3Ø
.4Ø
.5Ø
.6Ø
.7Ø
.8Ø

FIGURE 53

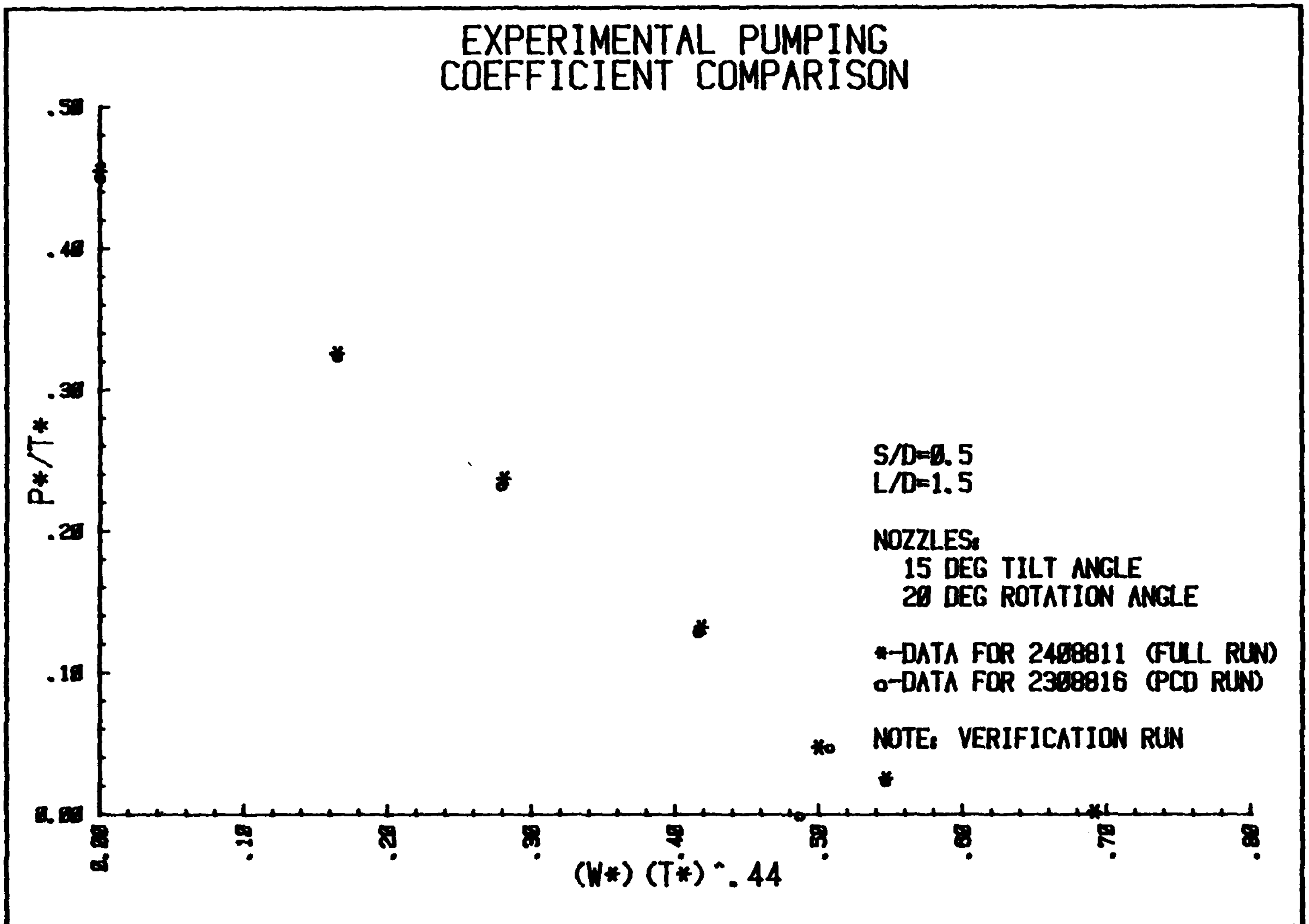

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*)^.44
S/D=0.5
L/D=1.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-DATA FOR 2408811 (FULL RUN)
o-DATA FOR 2308816 (PCD RUN)
NOTE: VERIFICATION RUN
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 53.1

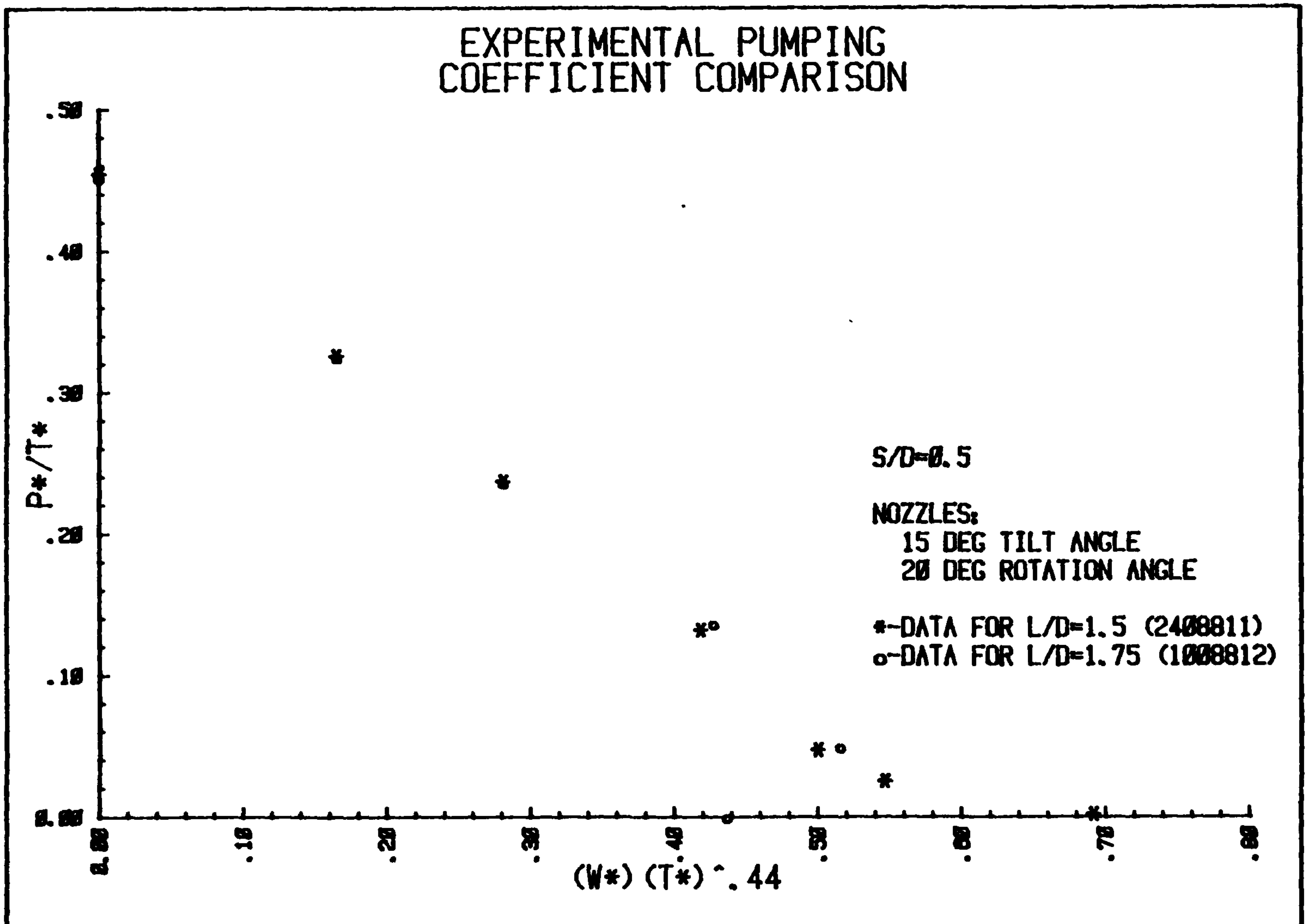

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-DATA FOR L/D=1.5 (2400811)
o-DATA FOR L/D=1.75 (1000812)

FIGURE 53.2

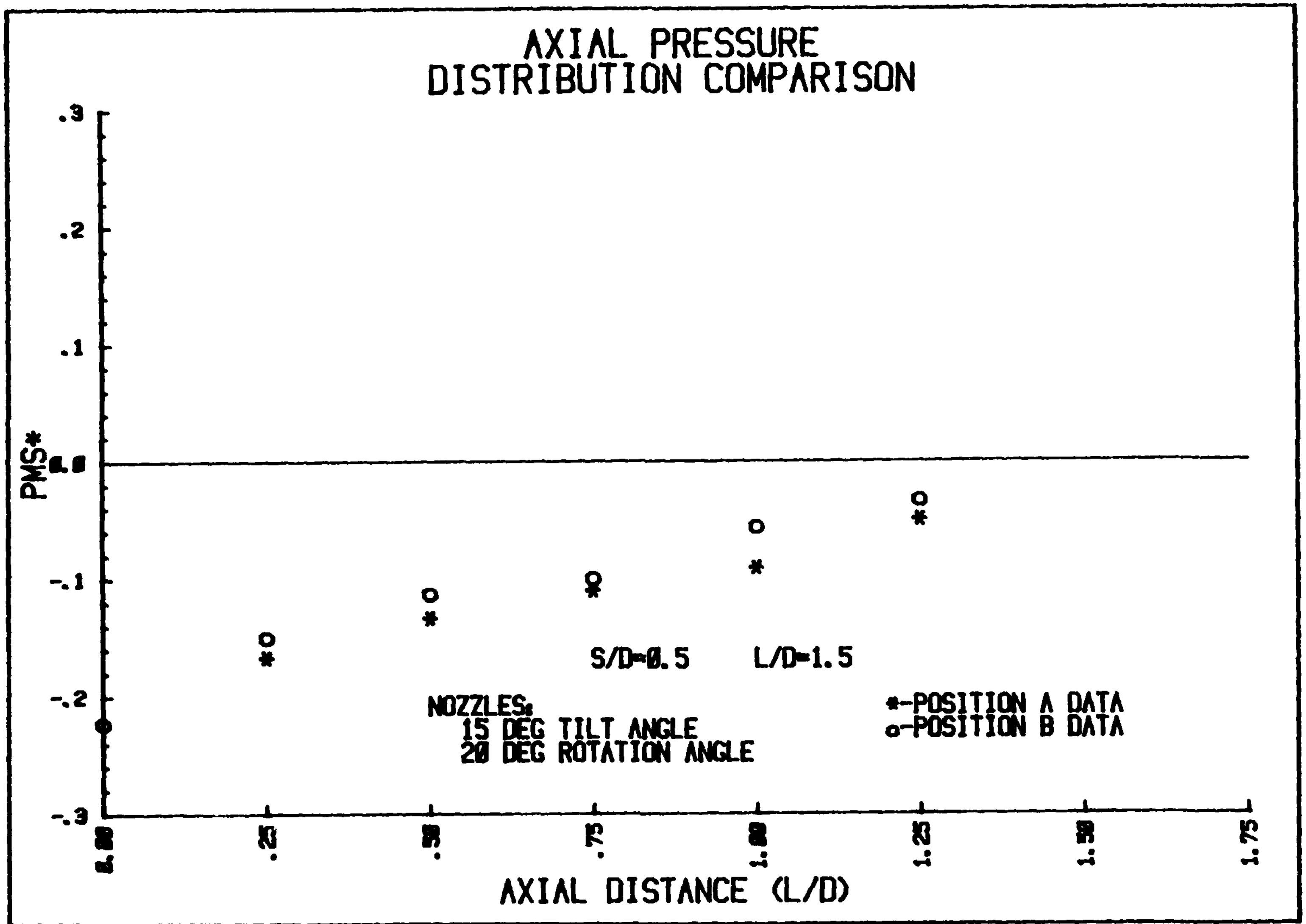

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
S/D=0.5
L/D=1.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 53.3

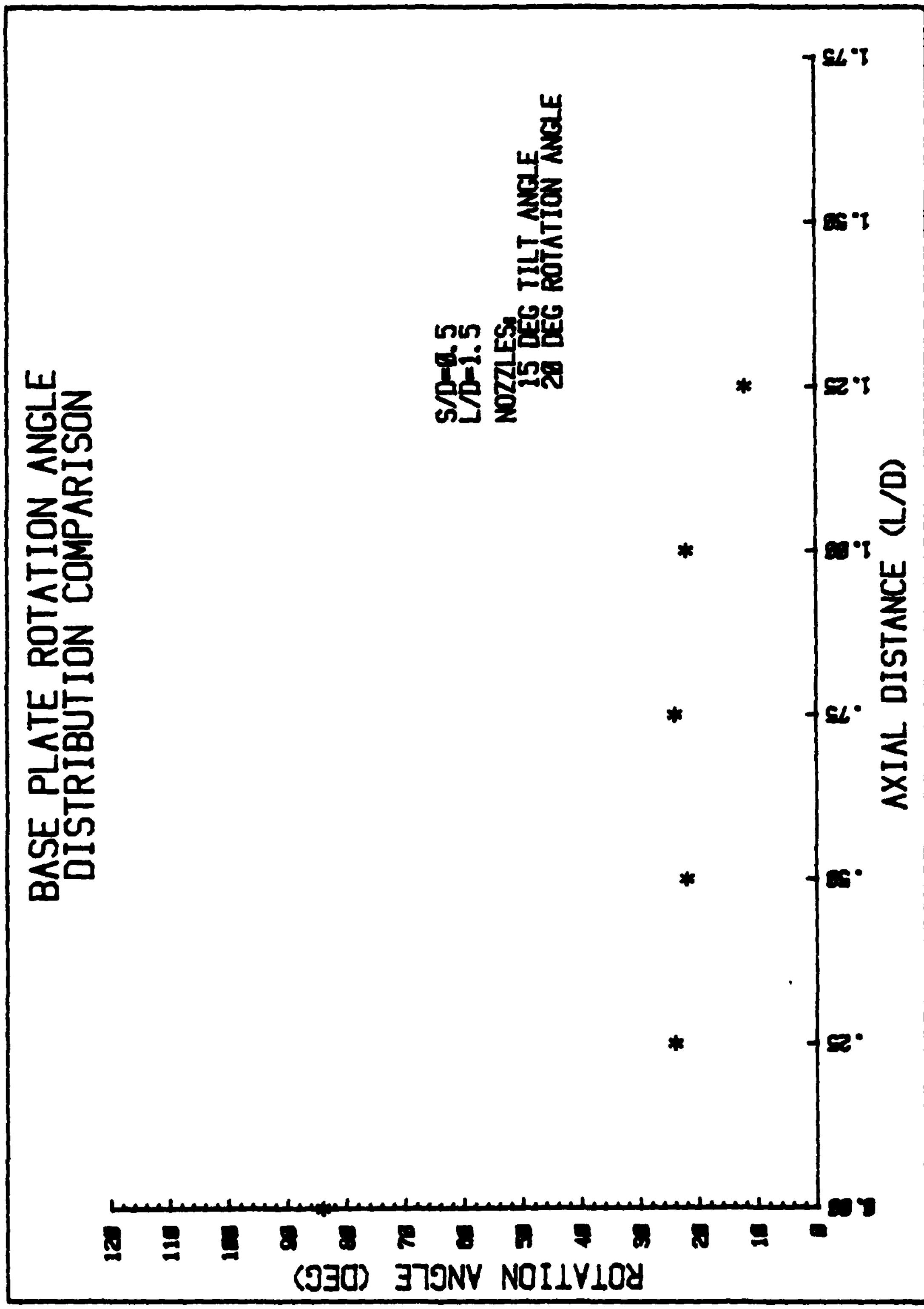
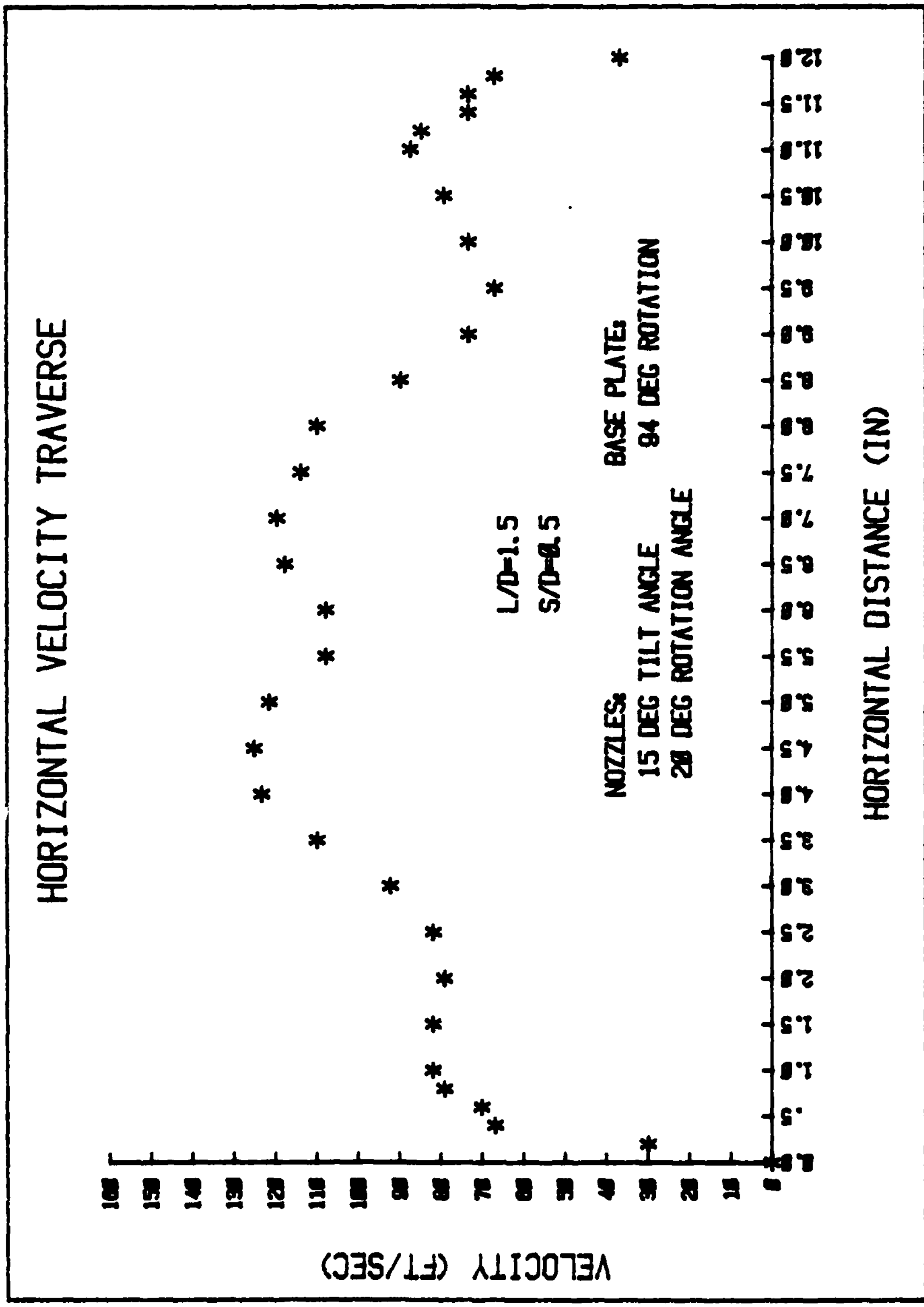

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
S/D=0.5
L/D=1.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
ROTATION ANGLE (DEG)
AXIAL DISTANCE (L/D)
0
10
20
30
40
50
60
70
80
90
100
110
120
0.00
.25
.50
.75
1.00
1.25
1.50
1.75

FIGURE 53.4



HORIZONTAL VELOCITY TRAVERSE
L/D=1.5
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
94 DEG ROTATION
HORIZONTAL DISTANCE (IN)
VELOCITY (FT/SEC)

FIGURE 53.5

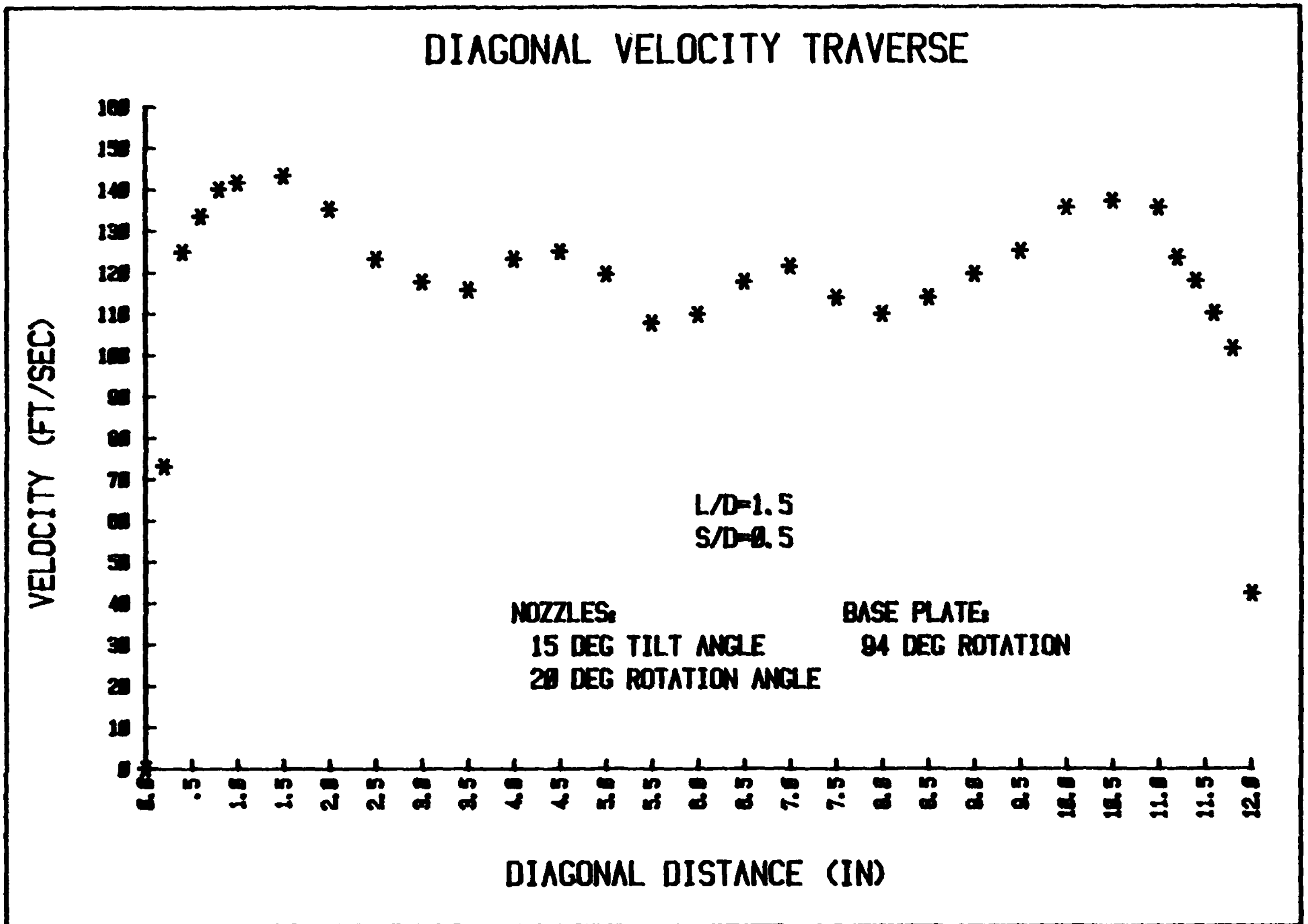

DIAGONAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)
L/D=1.5
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
94 DEG ROTATION

FIGURE 53.6

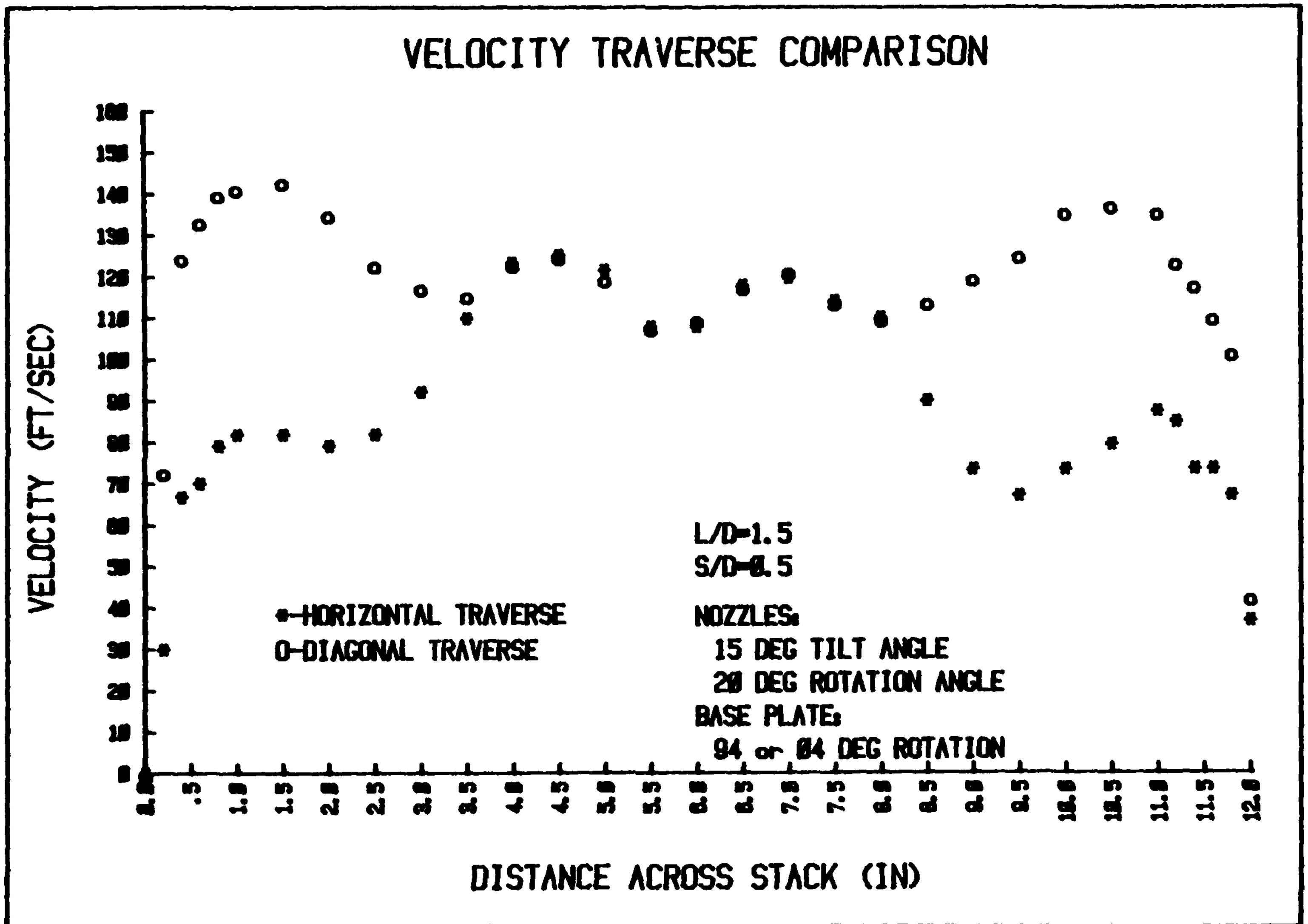

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.5
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
94 or 04 DEG ROTATION

FIGURE 53.7

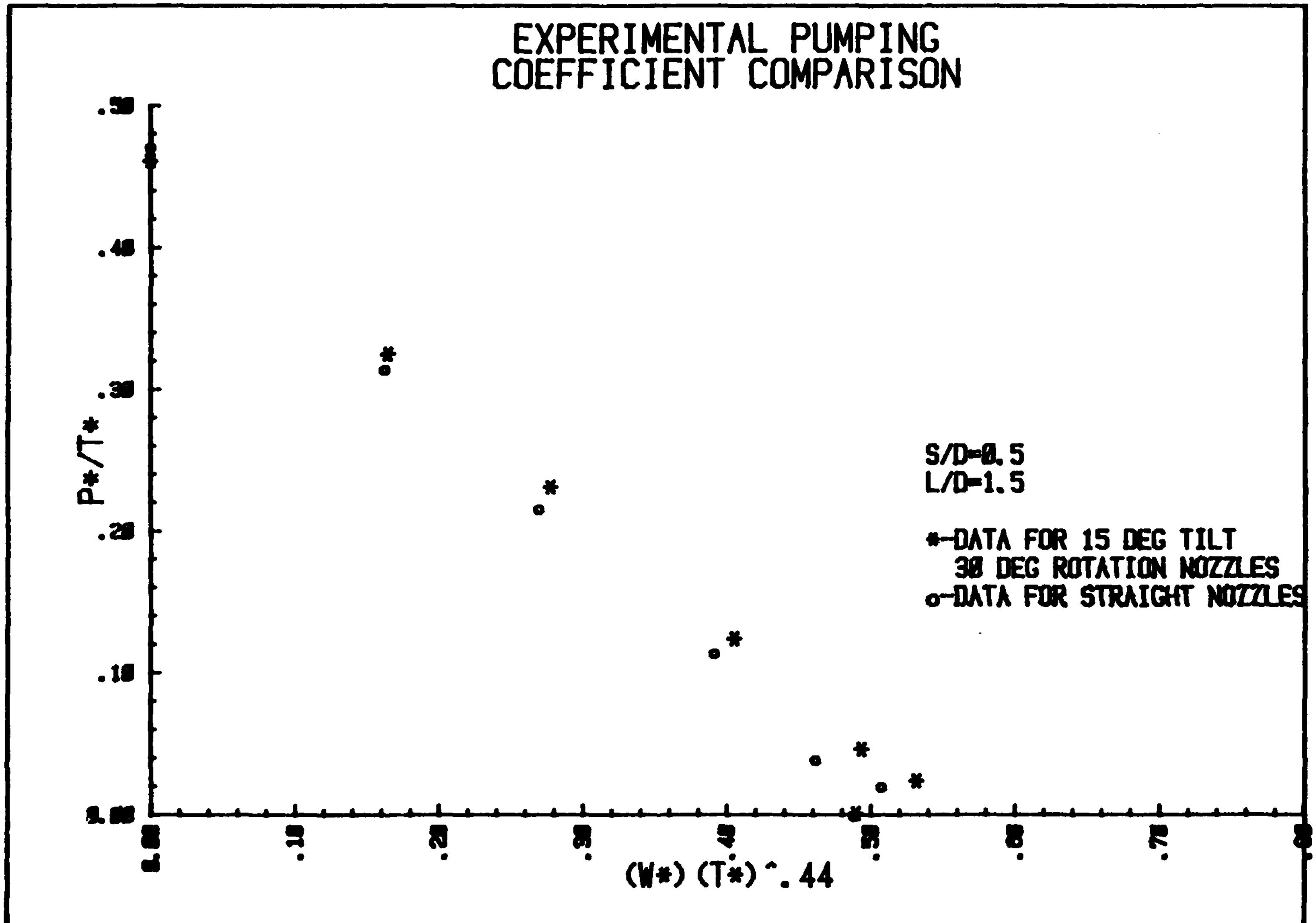

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 54

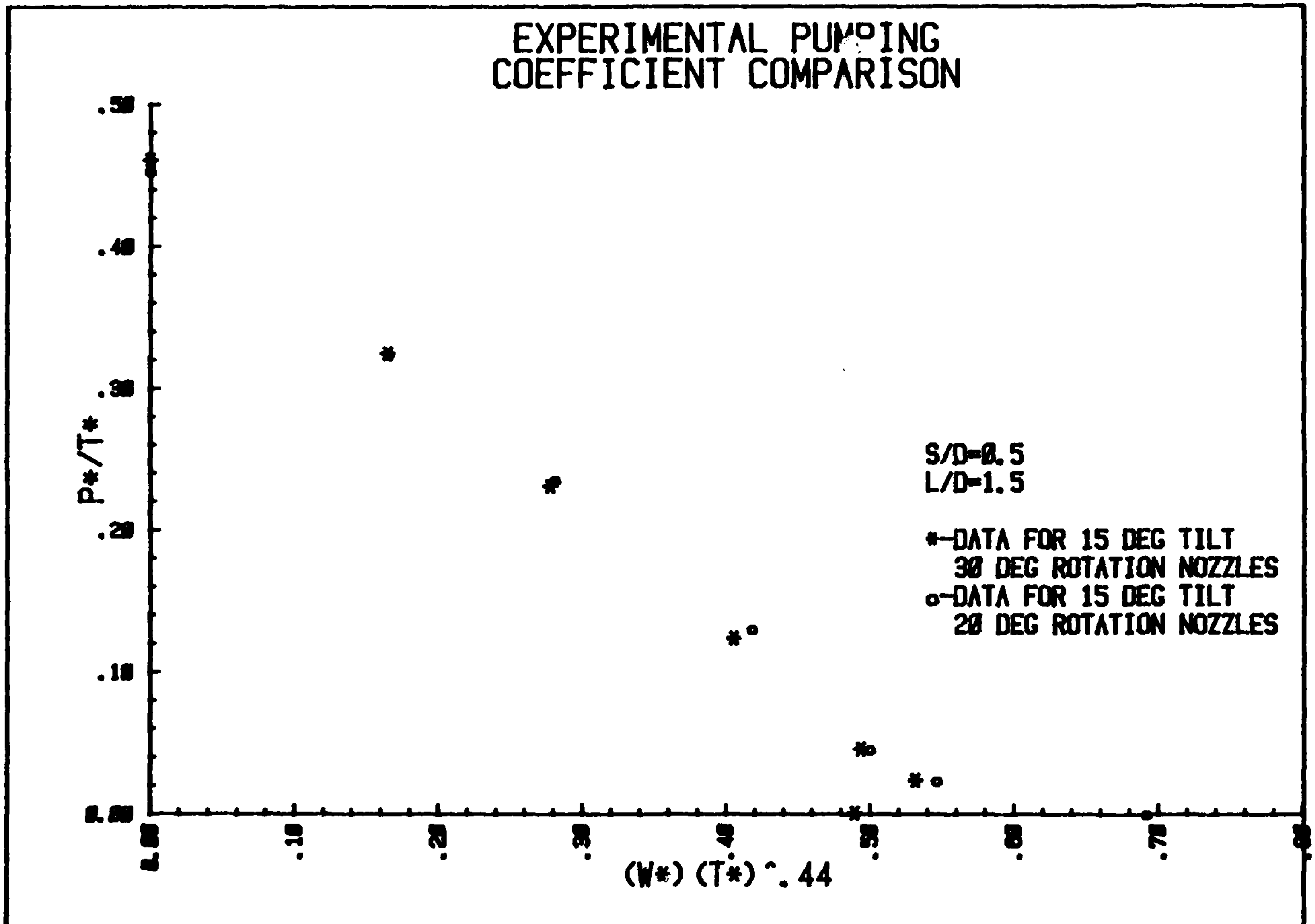

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.5
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 54.1

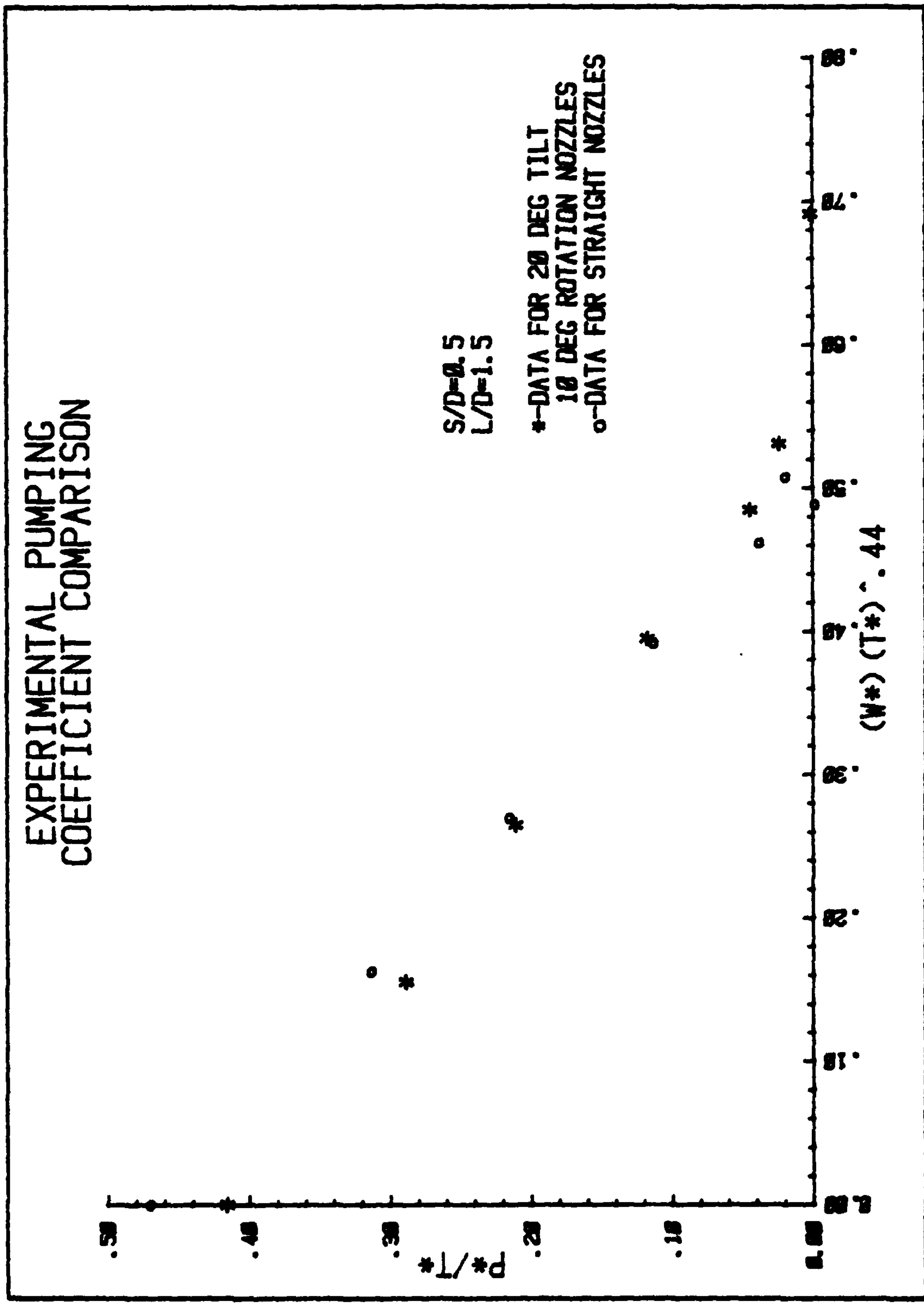
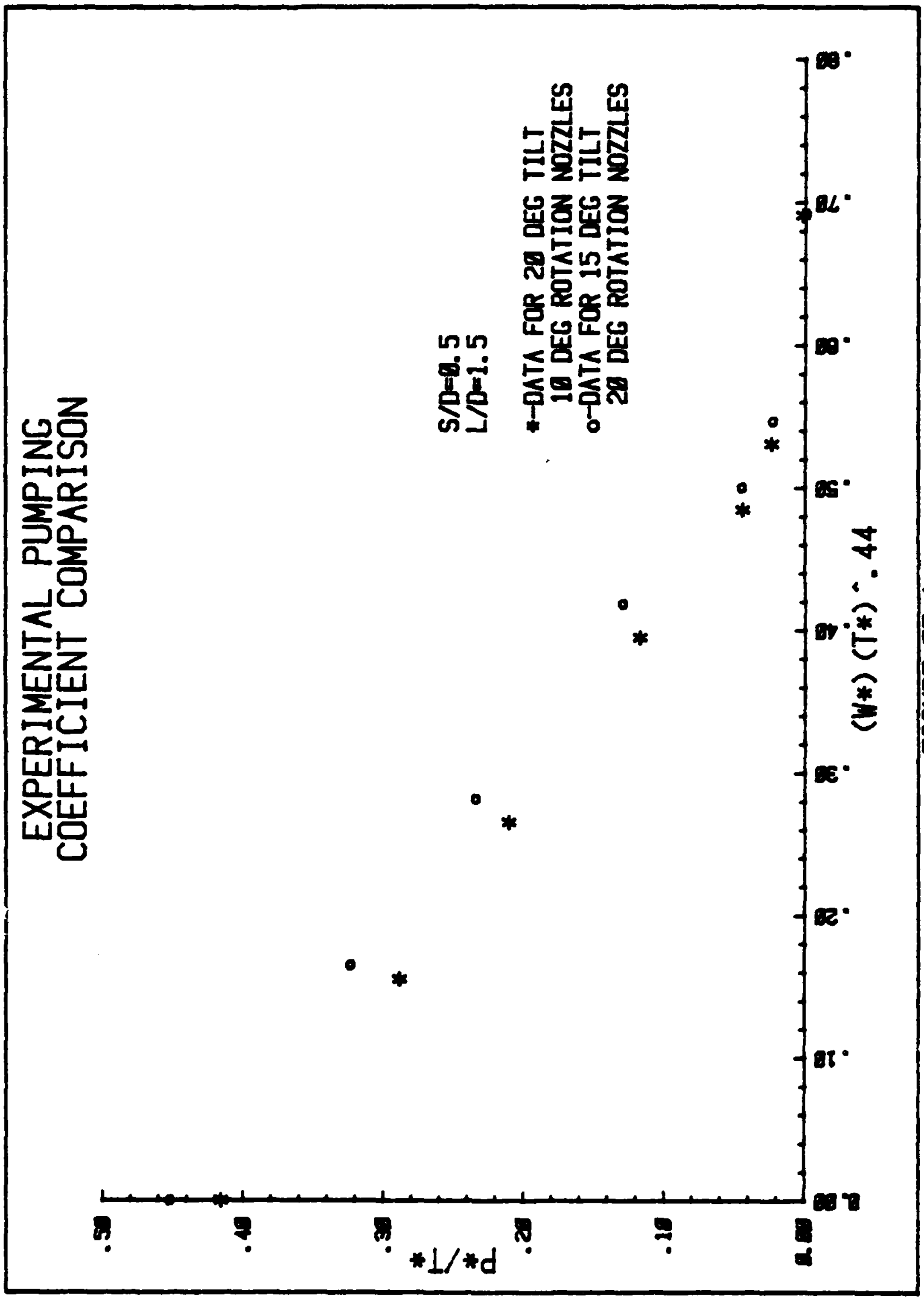

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
0.00
.10
.20
.30
.40
.50
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 55



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 55.1

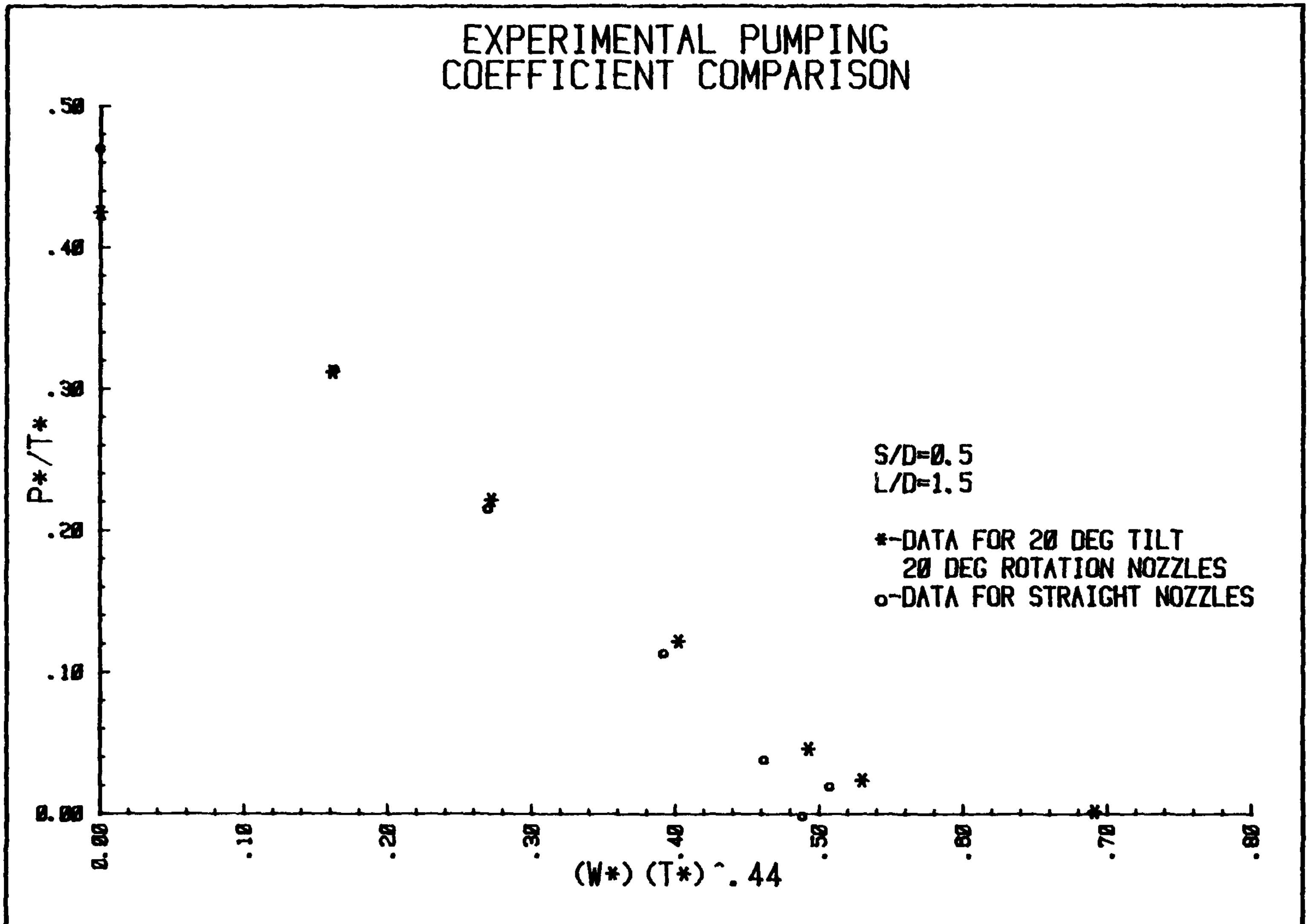

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 58

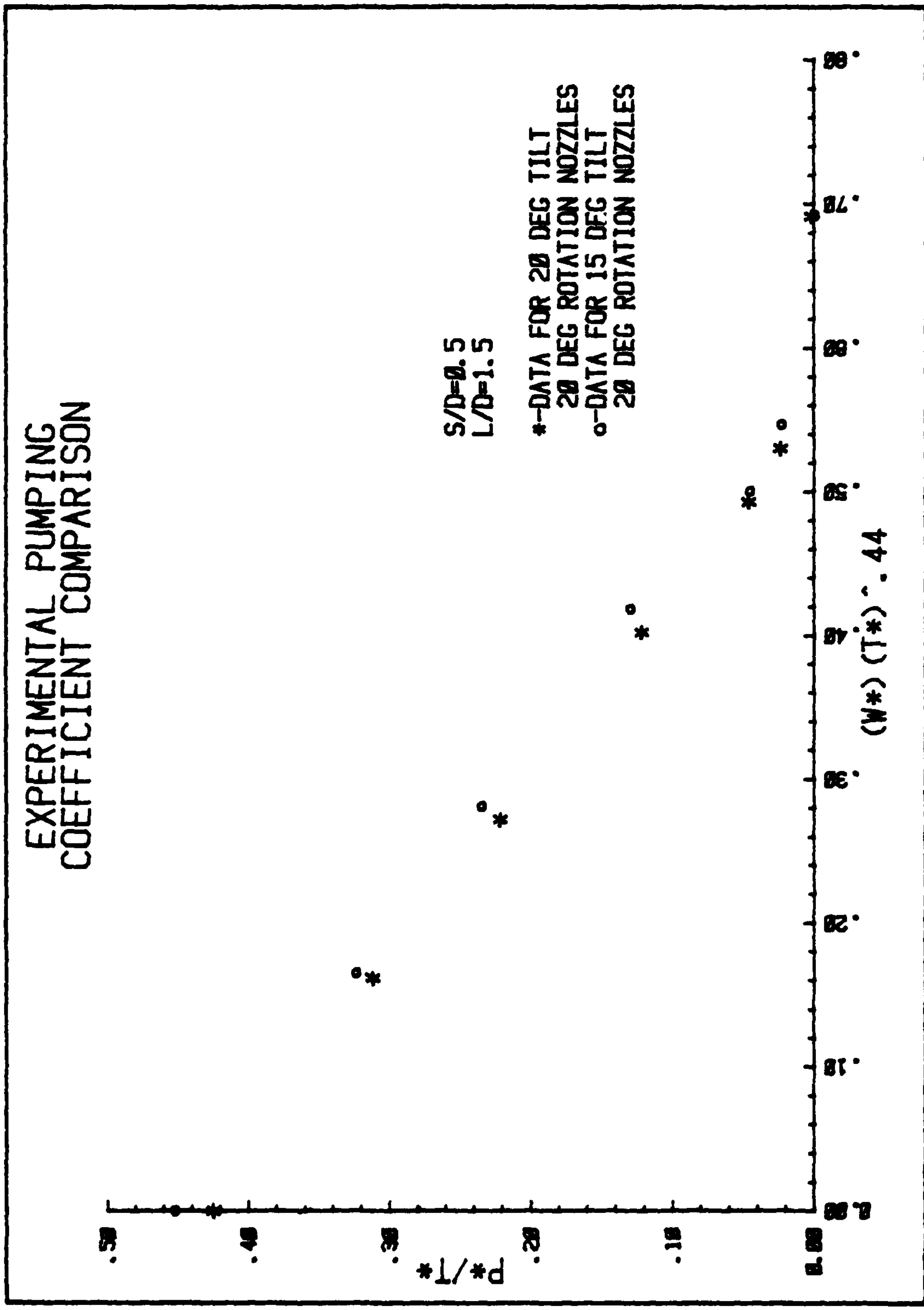

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
0.00
.10
.20
.30
.40
.50
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44

FIGURE 56.1

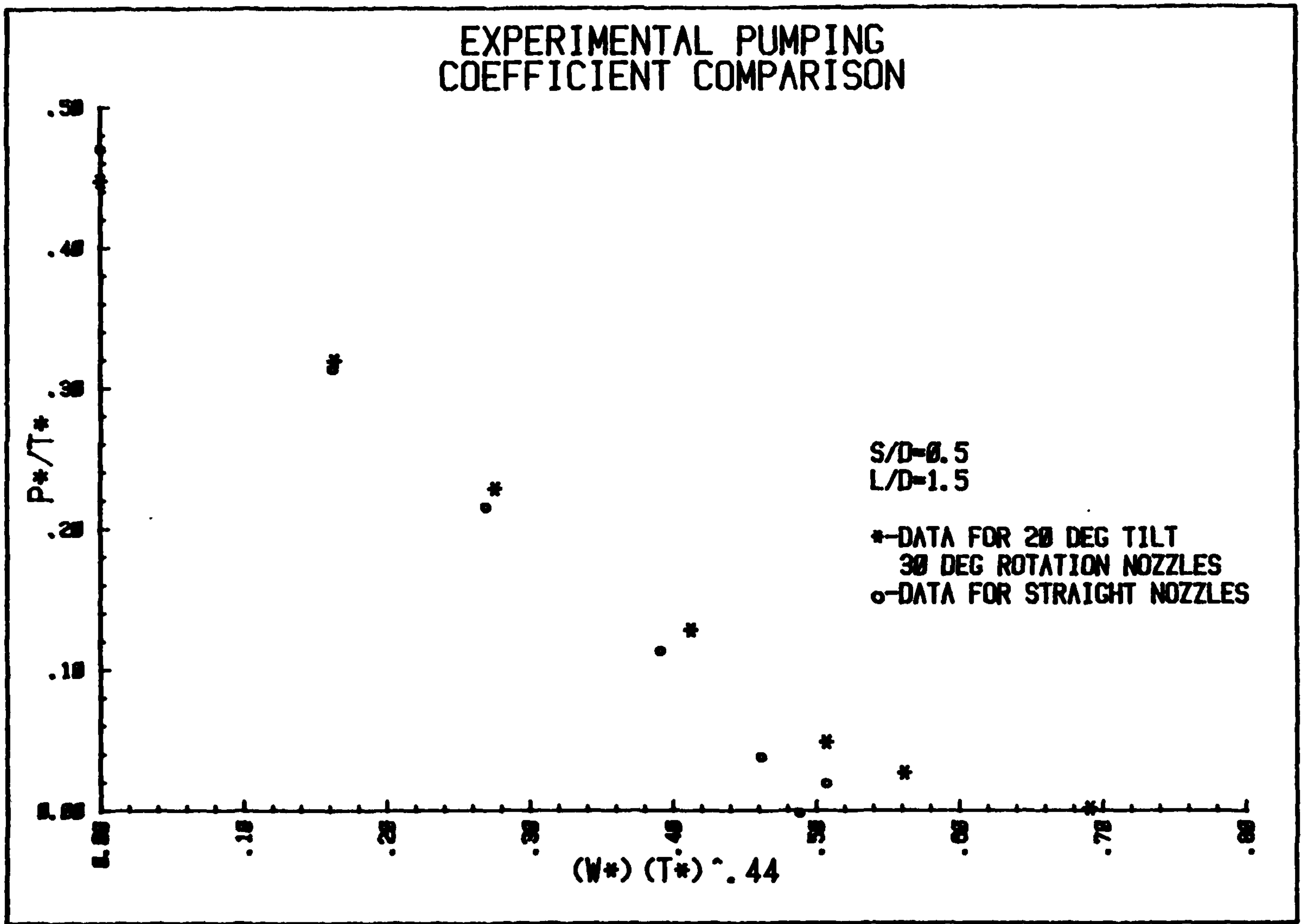
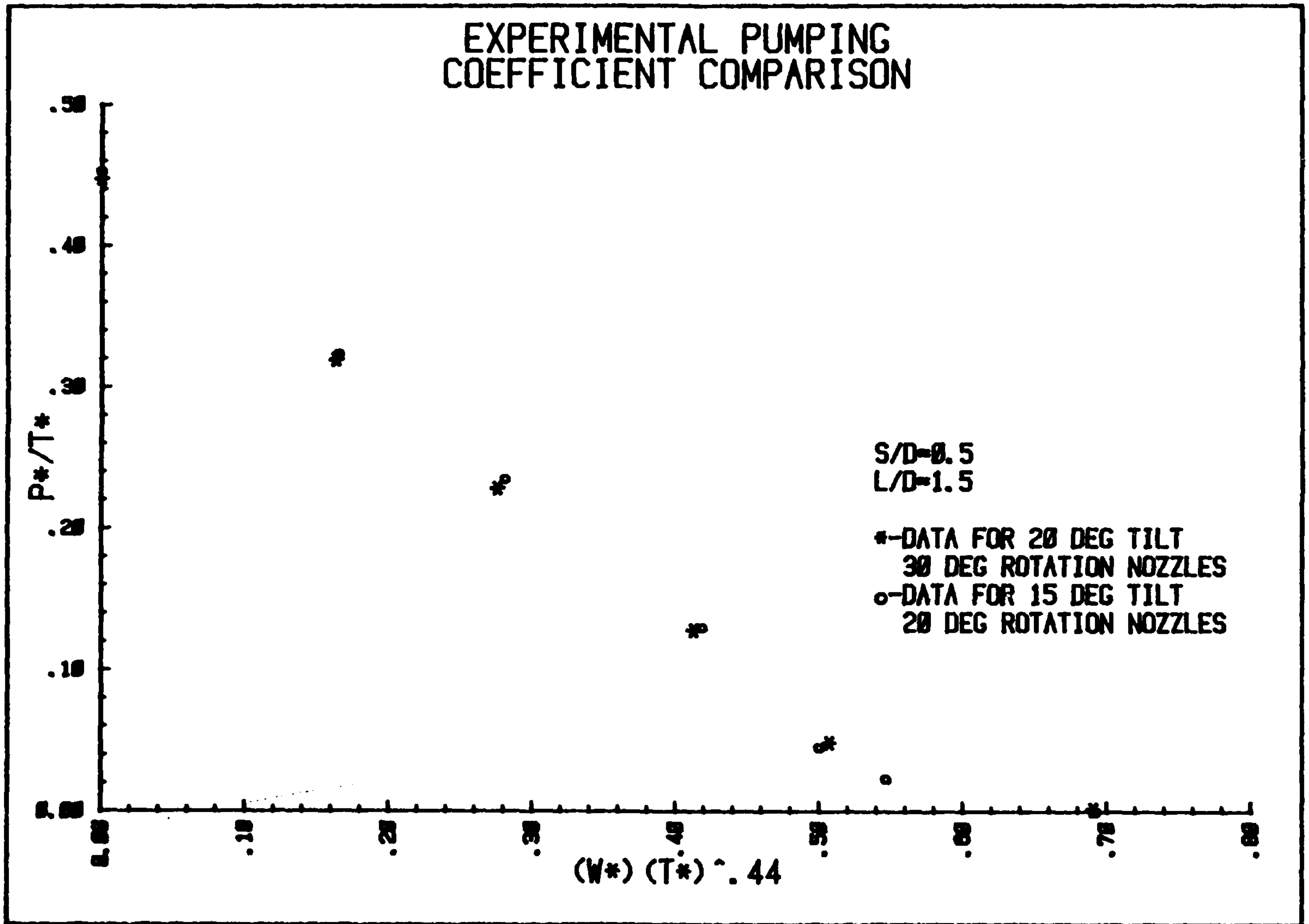

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*)(T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 57


EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.5
*-DATA FOR 20 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
FIGURE 57.1

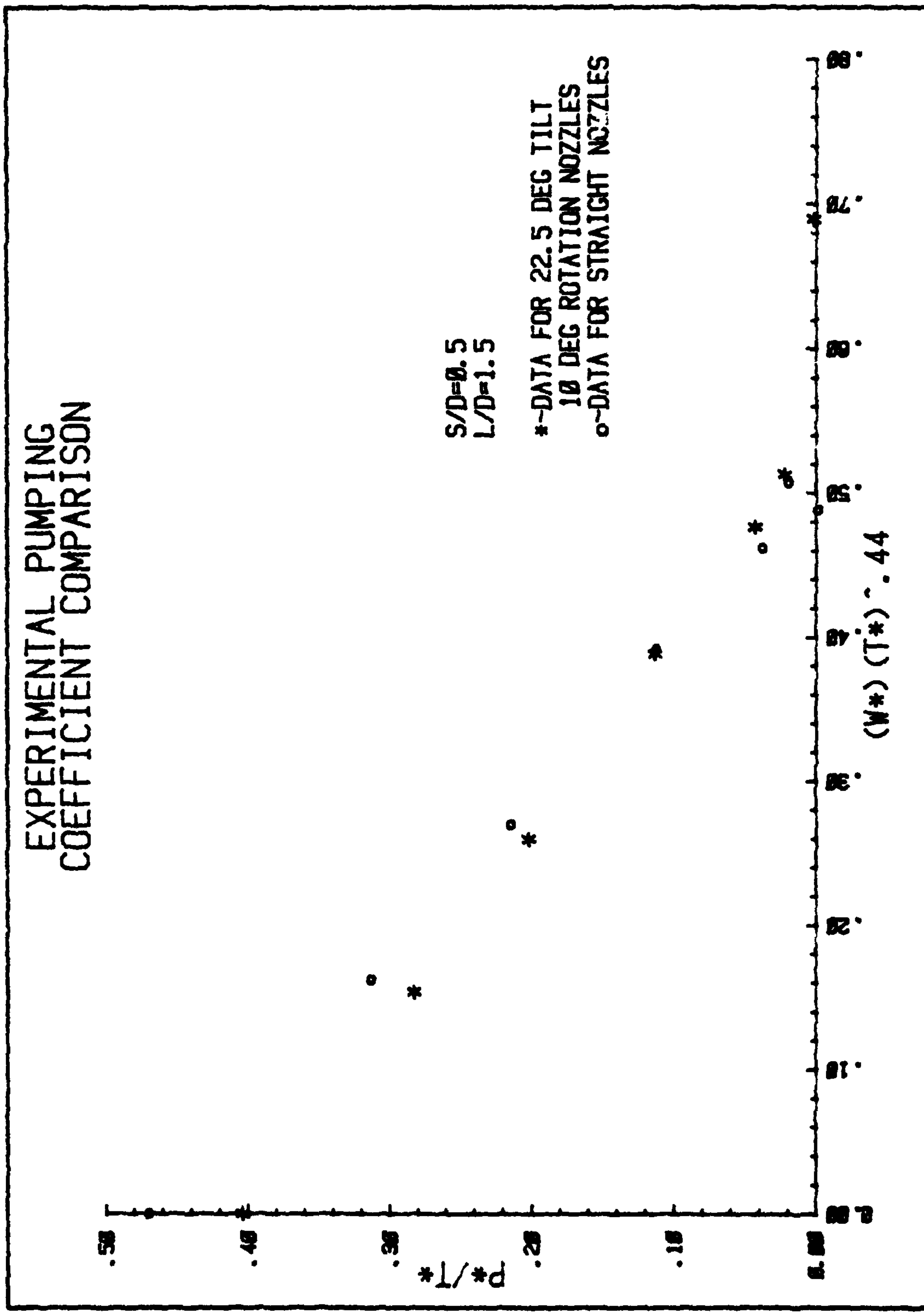

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=Ø.5
L/D=1.5
*-DATA FOR 22.5 DEG TILT
1Ø DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 58

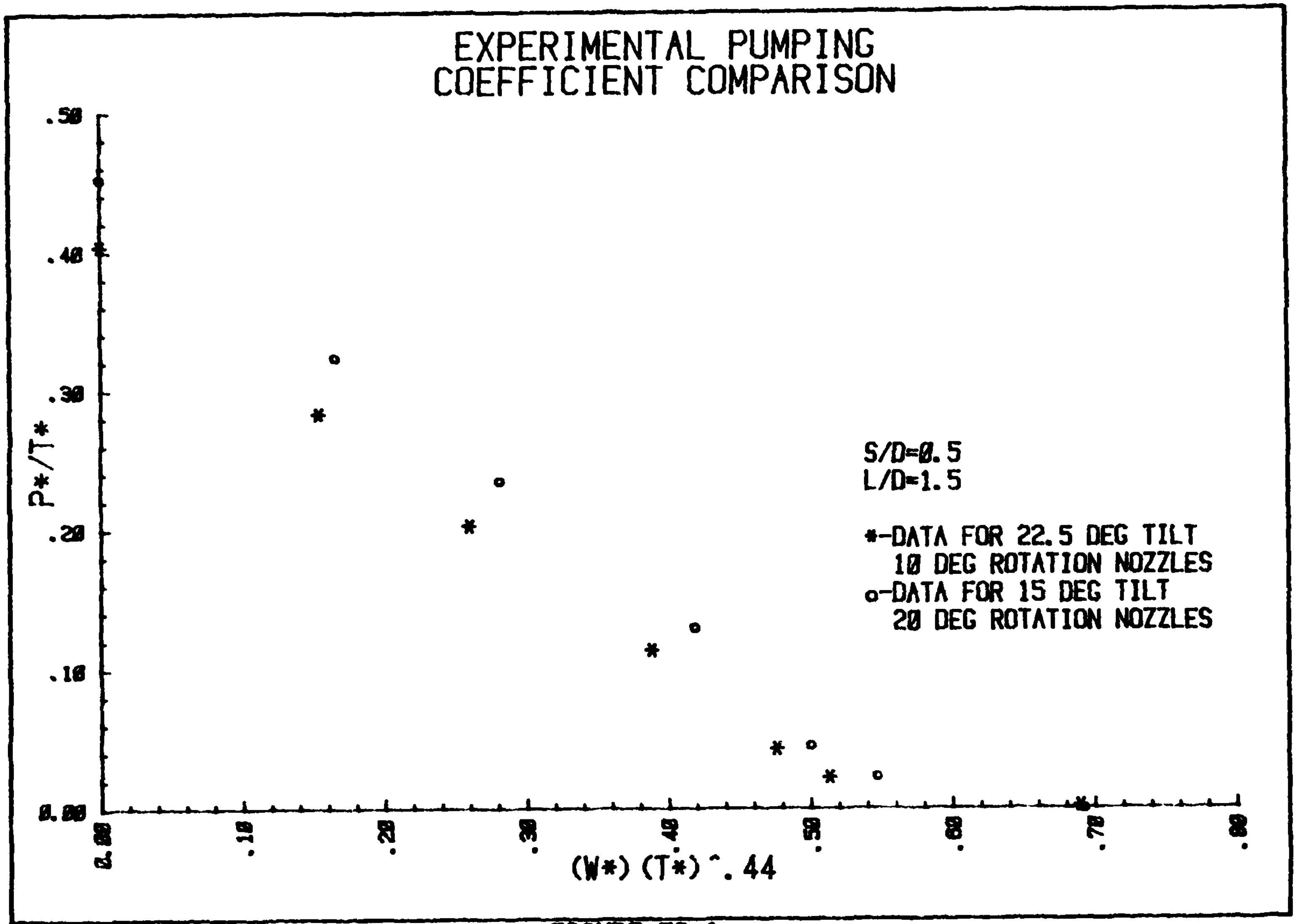

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.5
*-DATA FOR 22.5 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
(W*) (T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 58.1

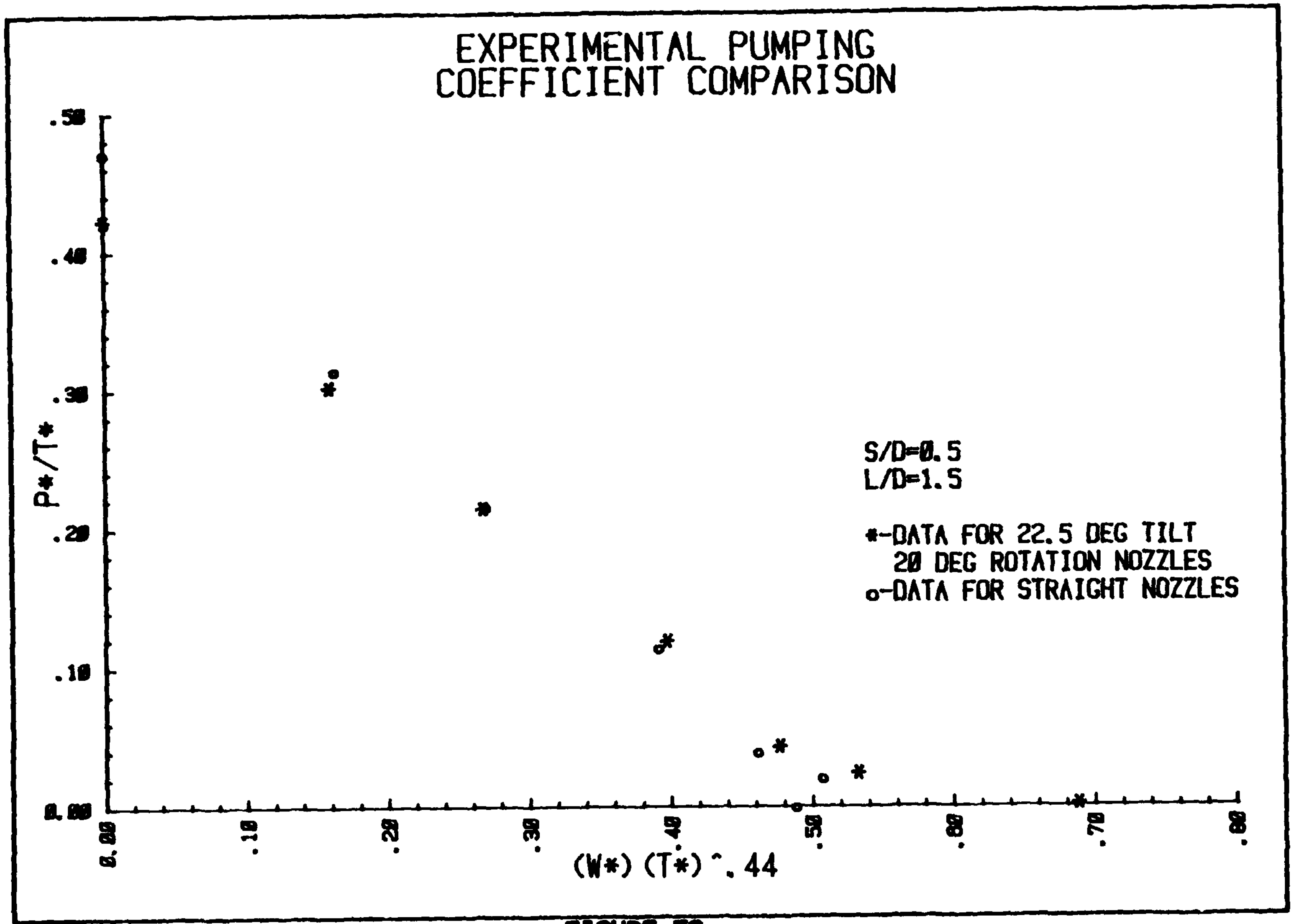

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 59

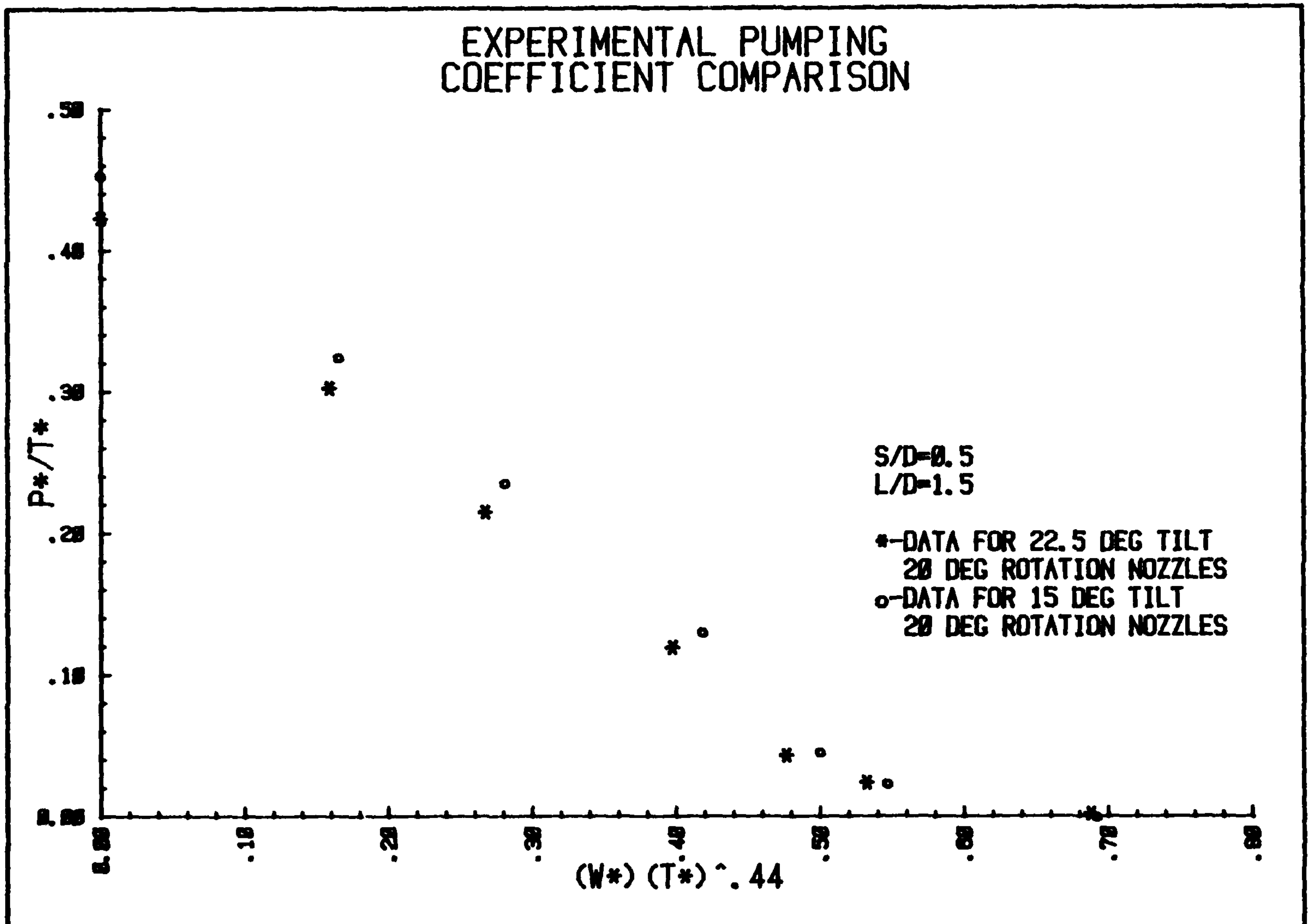
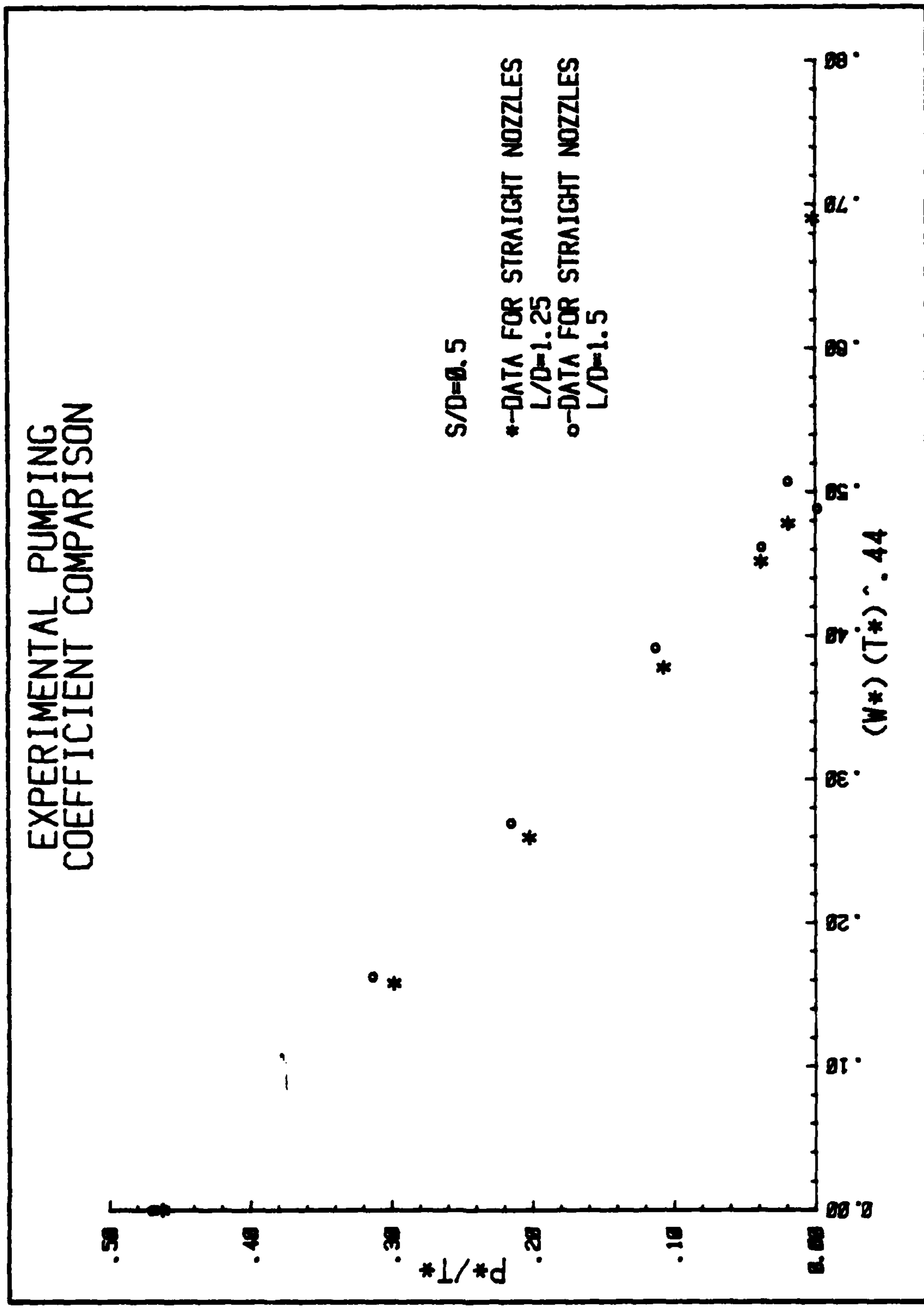

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.5
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES

FIGURE 59.1


EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
*-DATA FOR STRAIGHT NOZZLES
L/D=1.25
o-DATA FOR STRAIGHT NOZZLES
L/D=1.5
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44
FIGURE 60

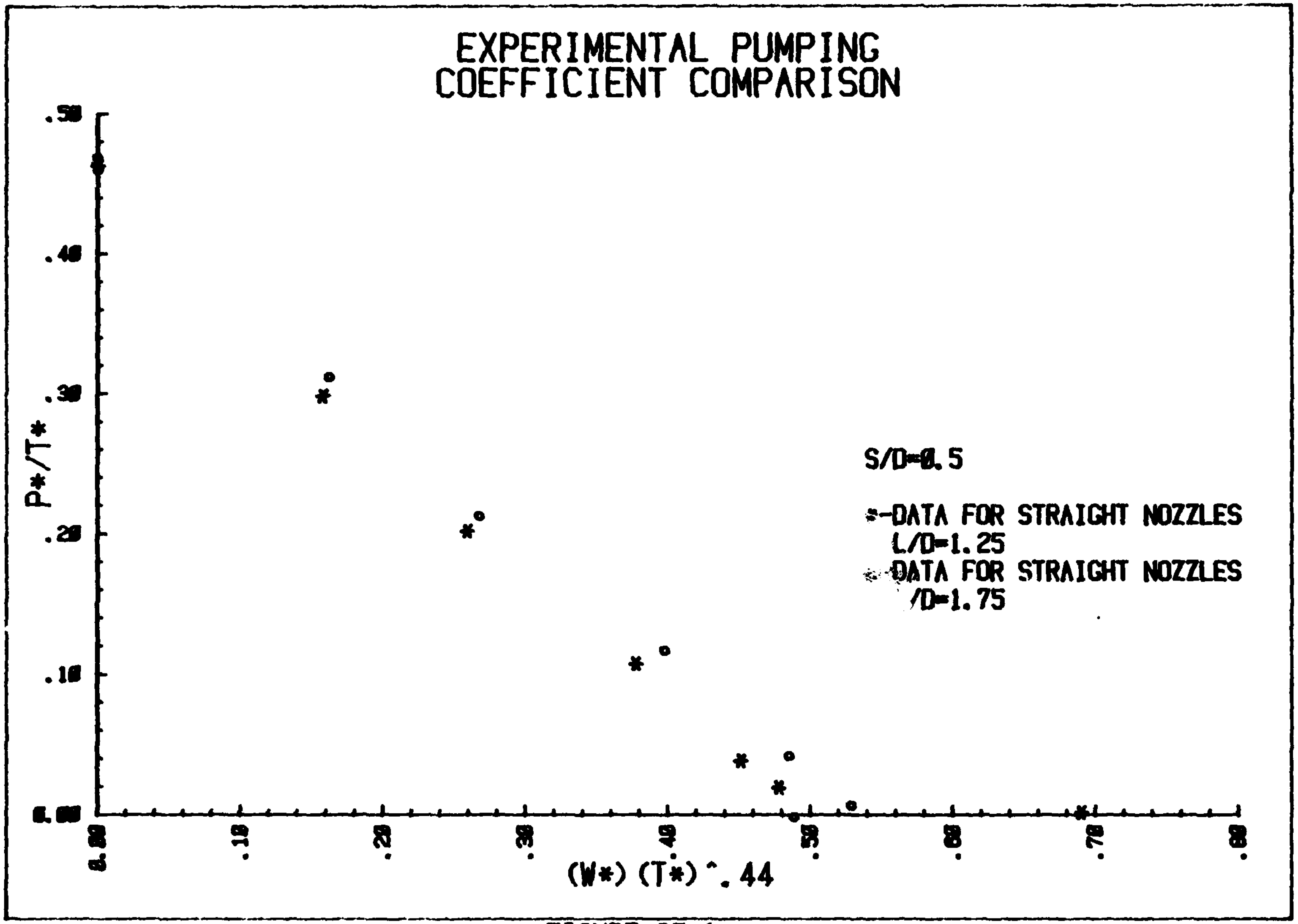

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
*-DATA FOR STRAIGHT NOZZLES
L/D=1.25
DATA FOR STRAIGHT NOZZLES
/D=1.75
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 60.1

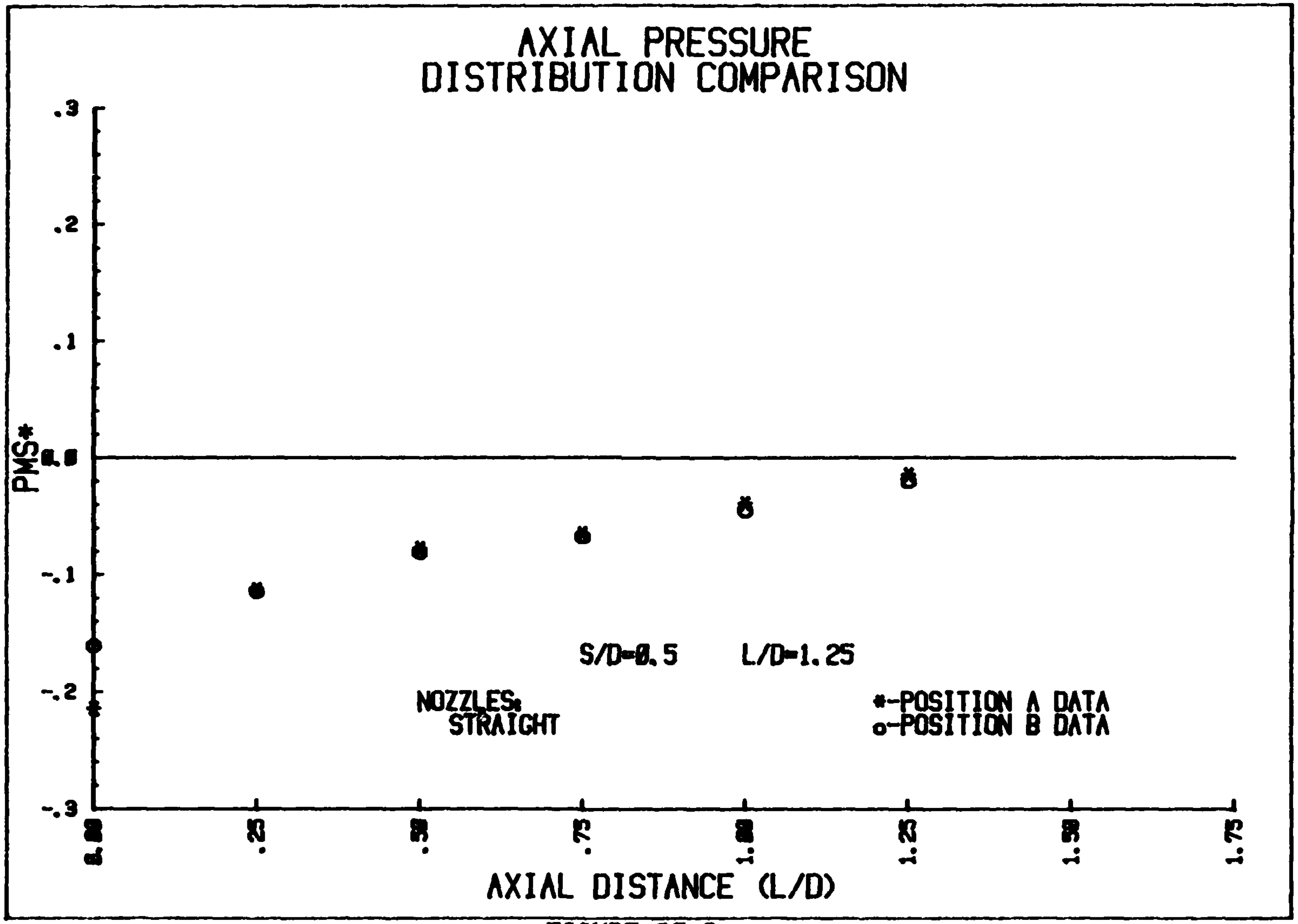
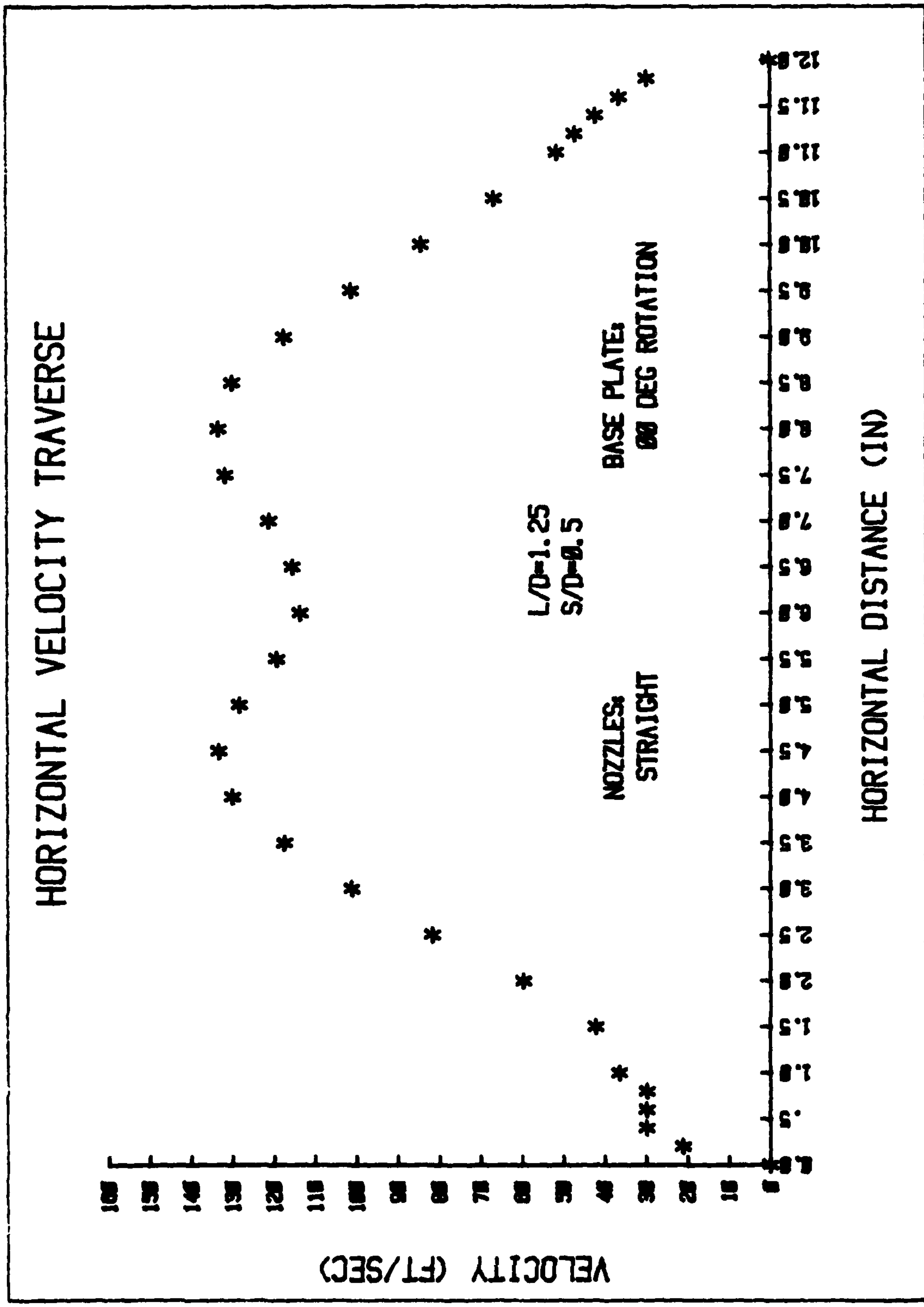

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)
S/D=0.5 L/D=1.25
NOZZLES:
STRAIGHT
*-POSITION A DATA
o-POSITION B DATA

FIGURE 60.2



HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
L/D=1.25
S/D=Ø.5
NOZZLES:
STRAIGHT
BASE PLATE:
ØØ DEG ROTATION

FIGURE 6Ø.3

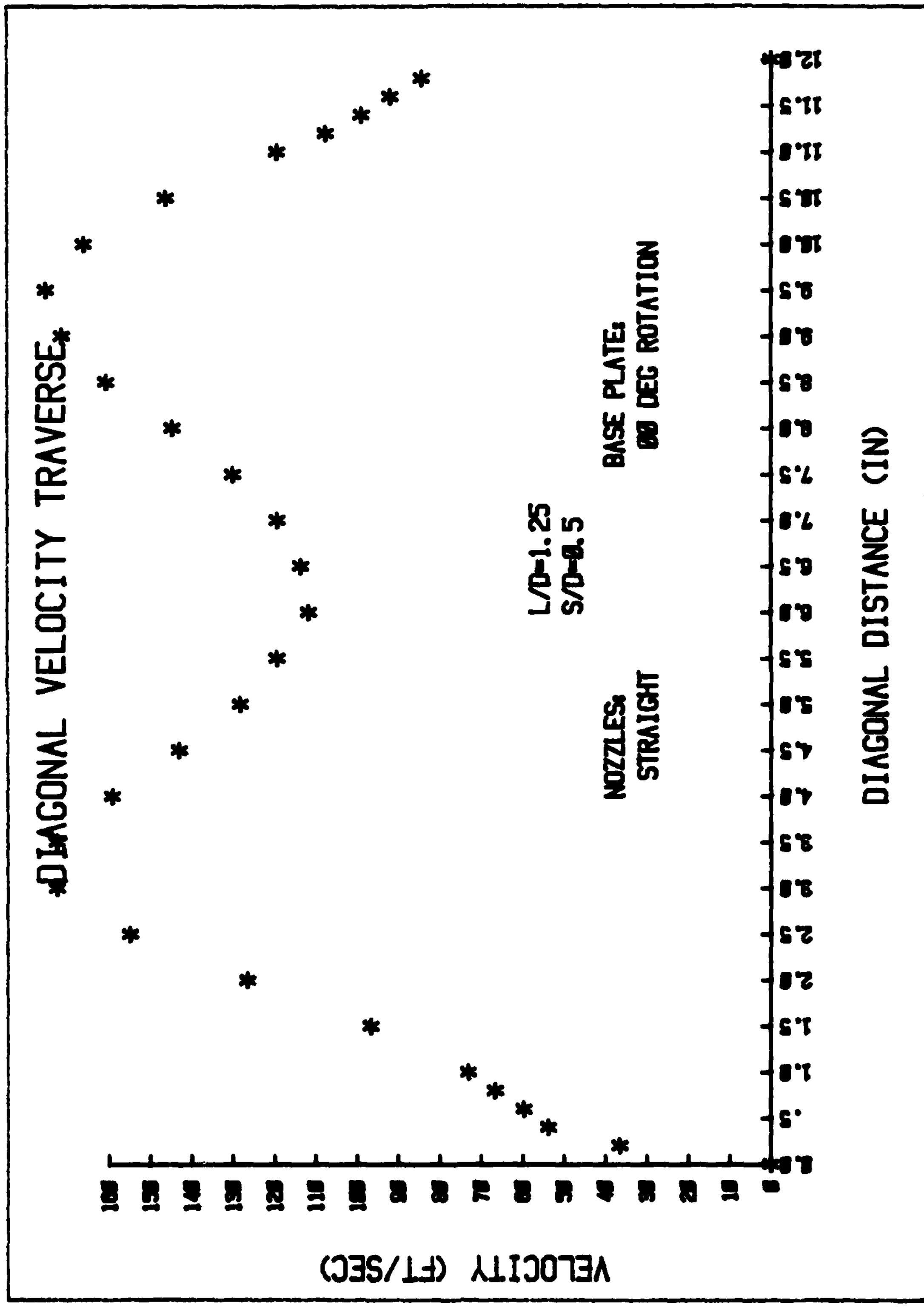

DIAGONAL VELOCITY TRAVERSE
L/D=1.25
S/D=0.5
NOZZLES: STRAIGHT
BASE PLATE: 00 DEG ROTATION
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)

FIGURE 60.4

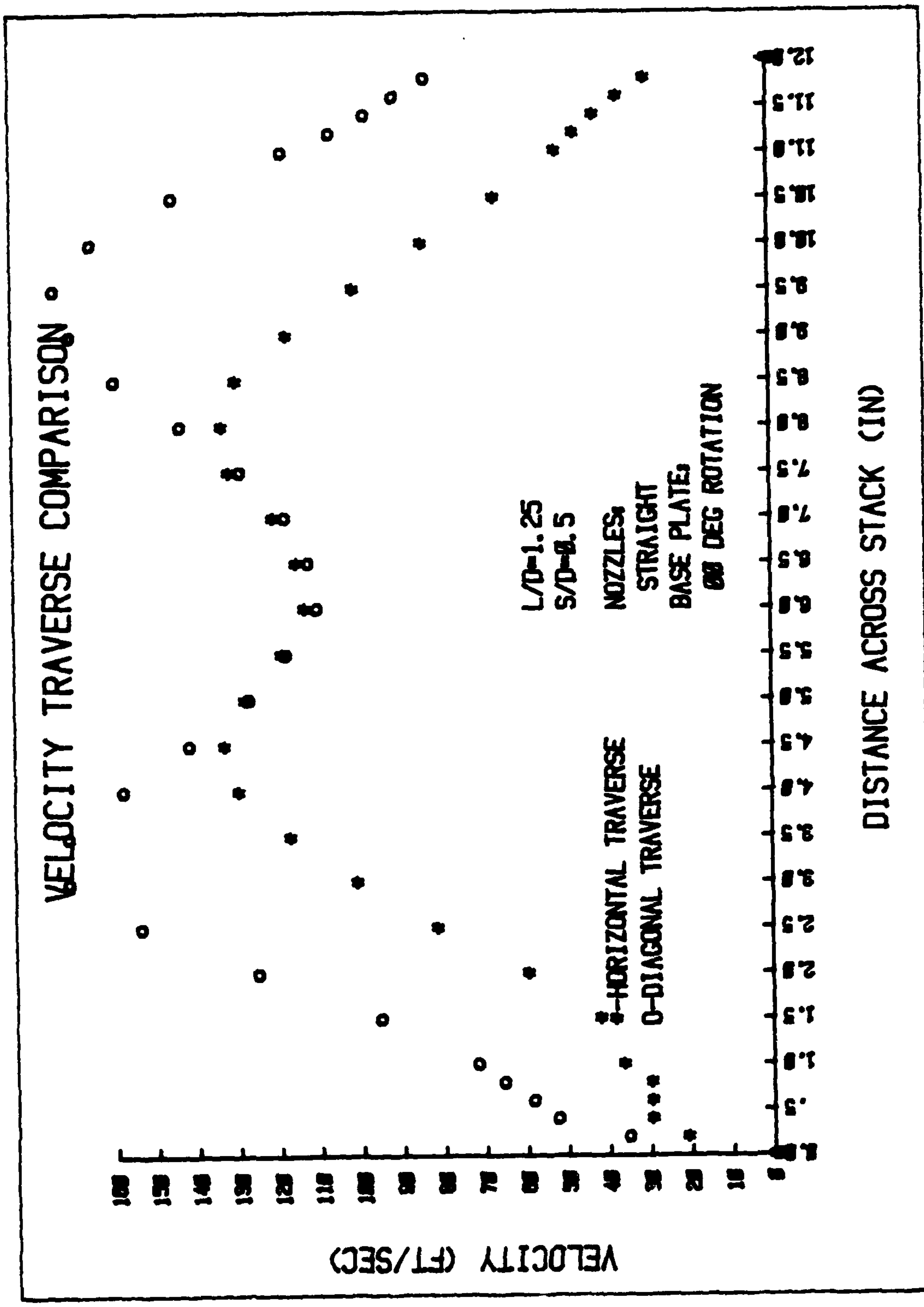

VELOCITY TRAVERSE COMPARISON
L/D=1.25
S/D=0.5
NOZZLES:
STRAIGHT
BASE PLATE:
00 DEG ROTATION
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
DISTANCE ACROSS STACK (IN)
VELOCITY (FT/SEC)

FIGURE 60.5

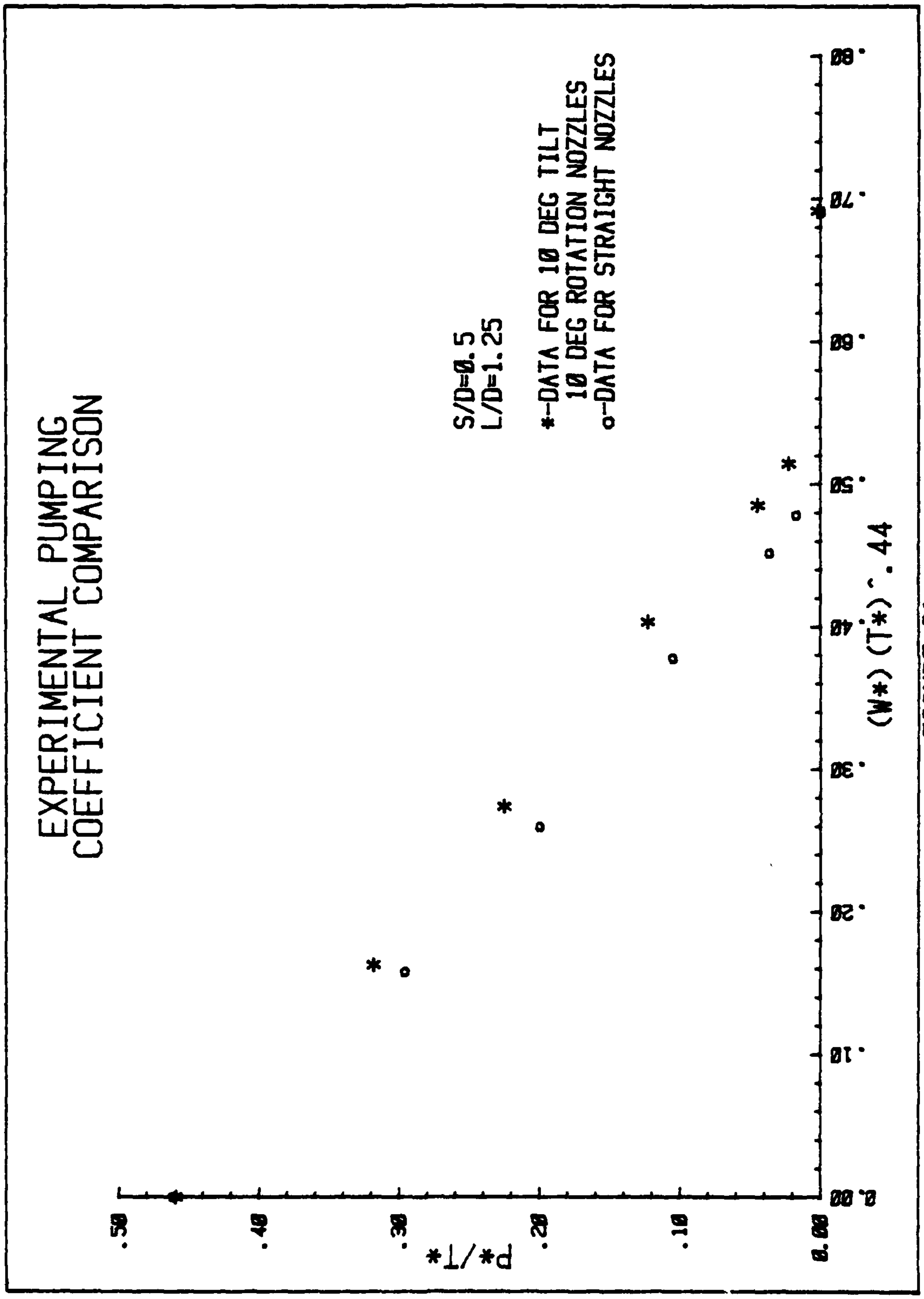
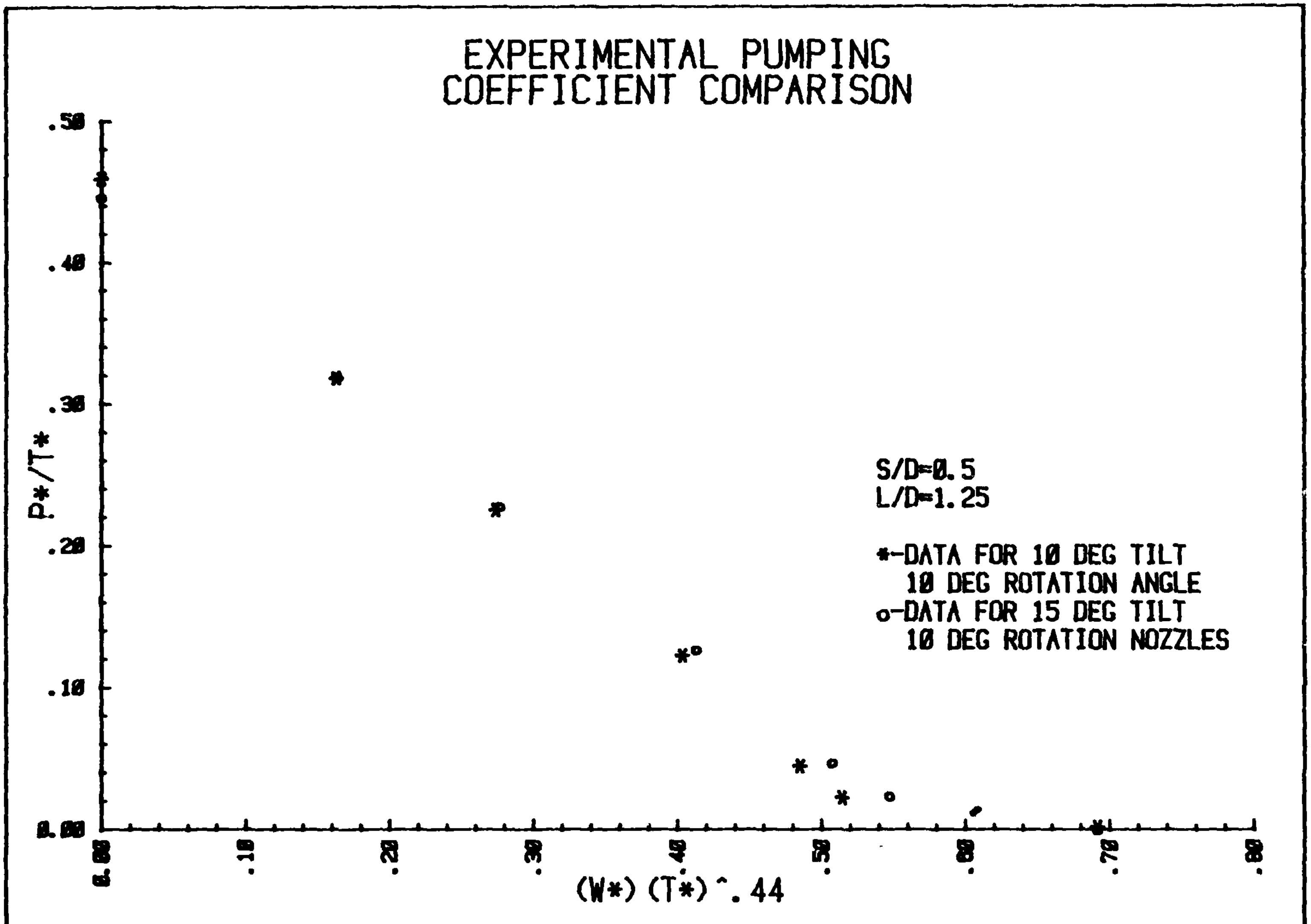

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 61



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
10 DEG ROTATION ANGLE
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
(W*) (T*)^.44
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 61.1

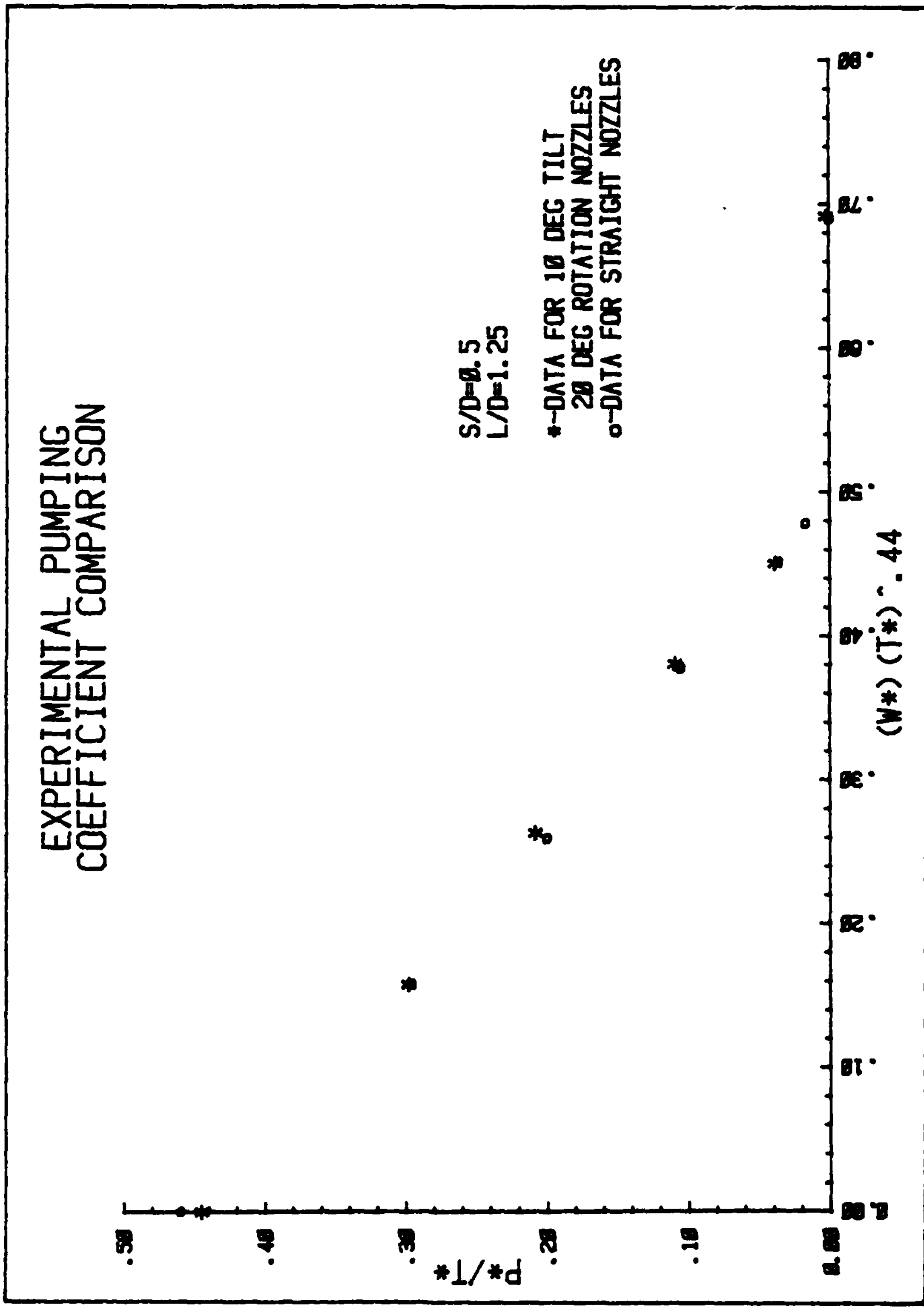
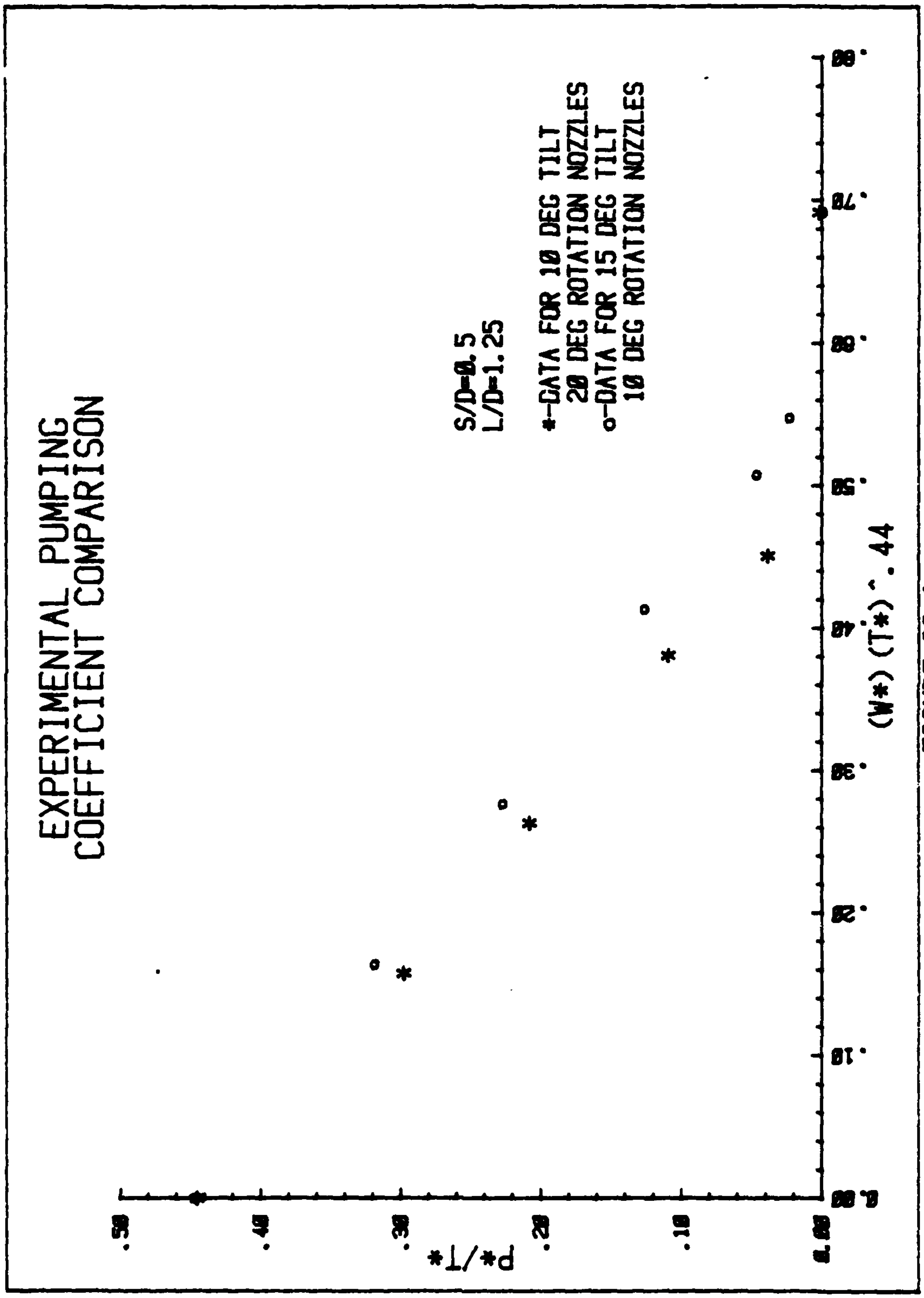

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44

FIGURE 62



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE B2.1

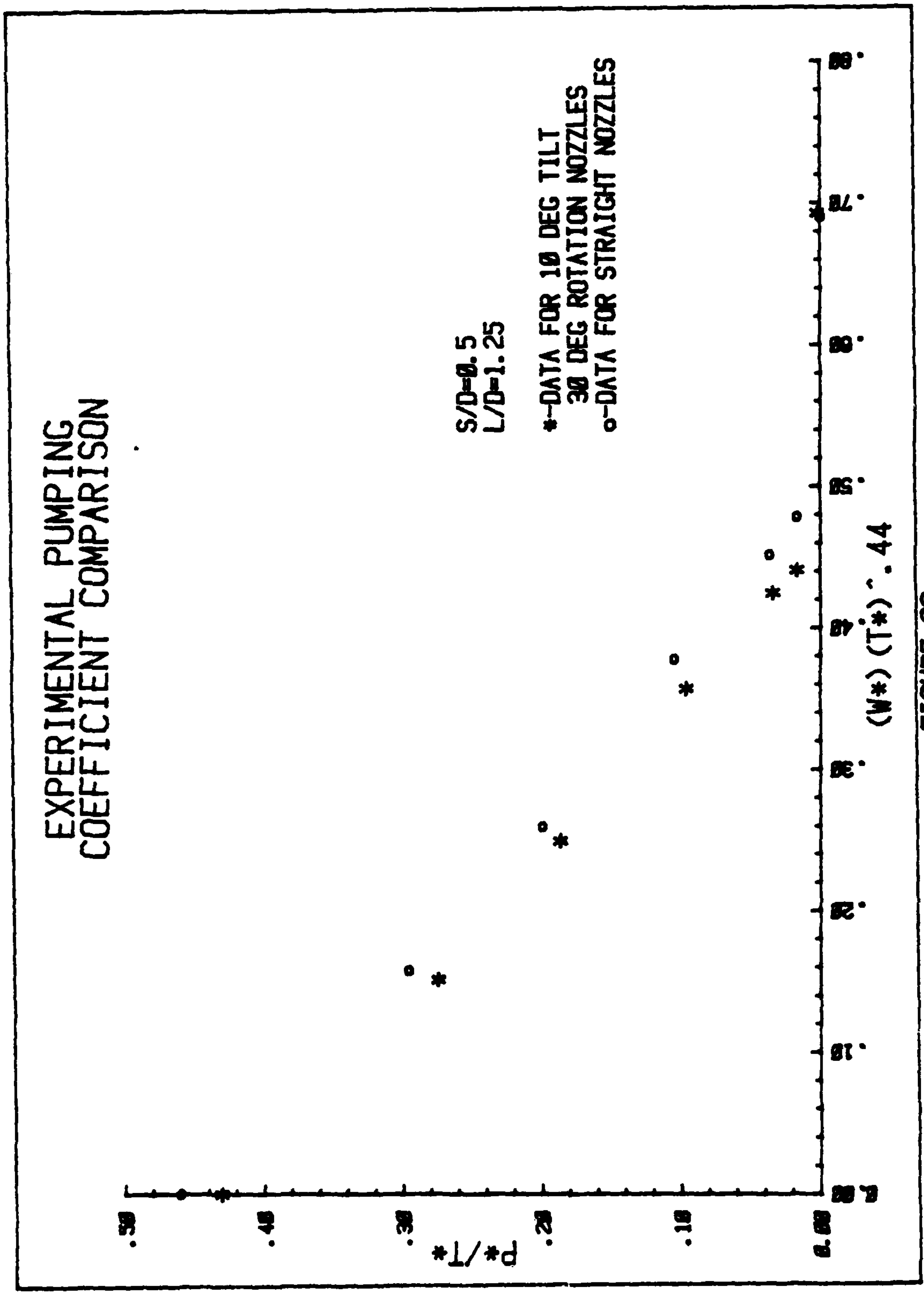

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 63

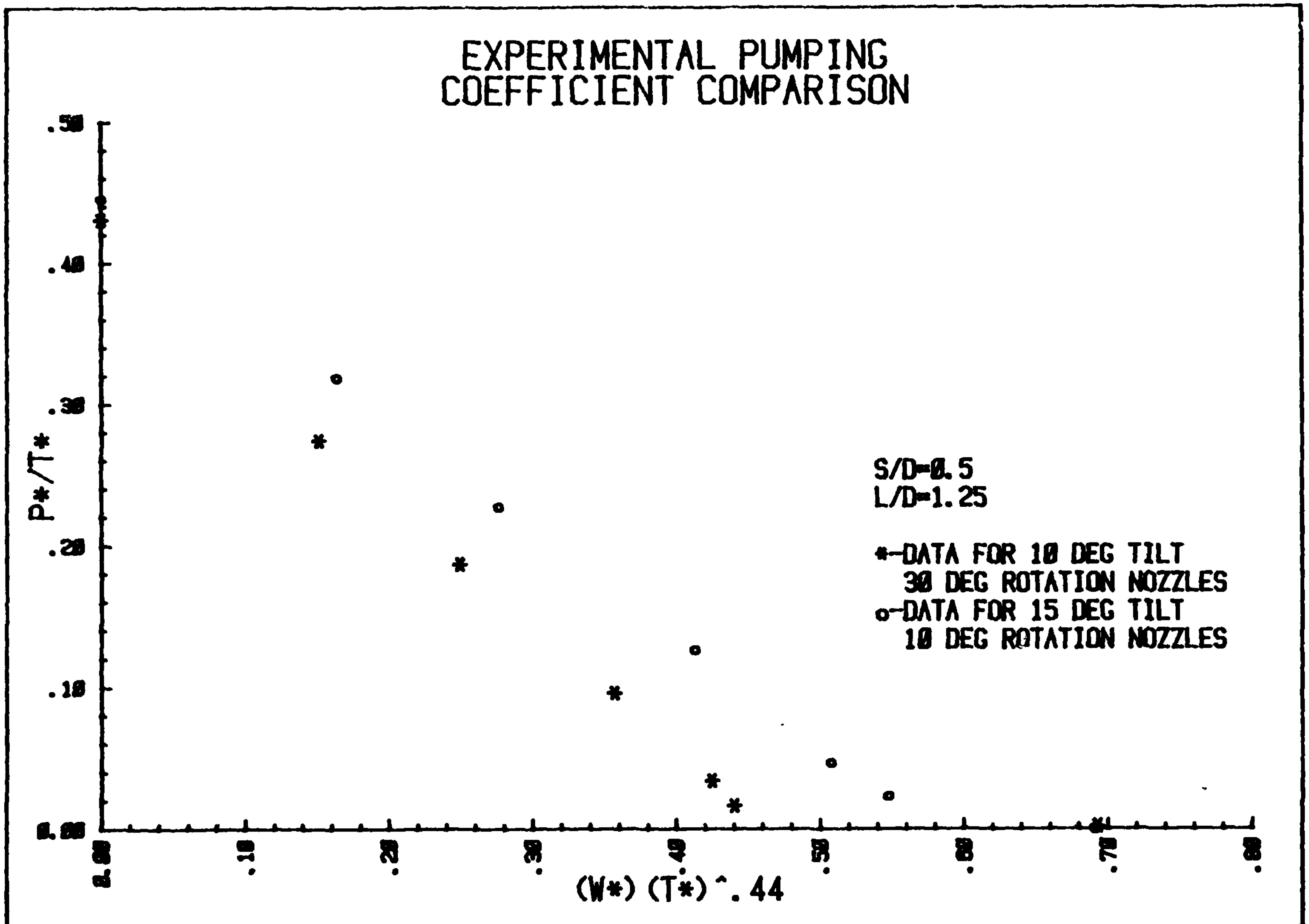
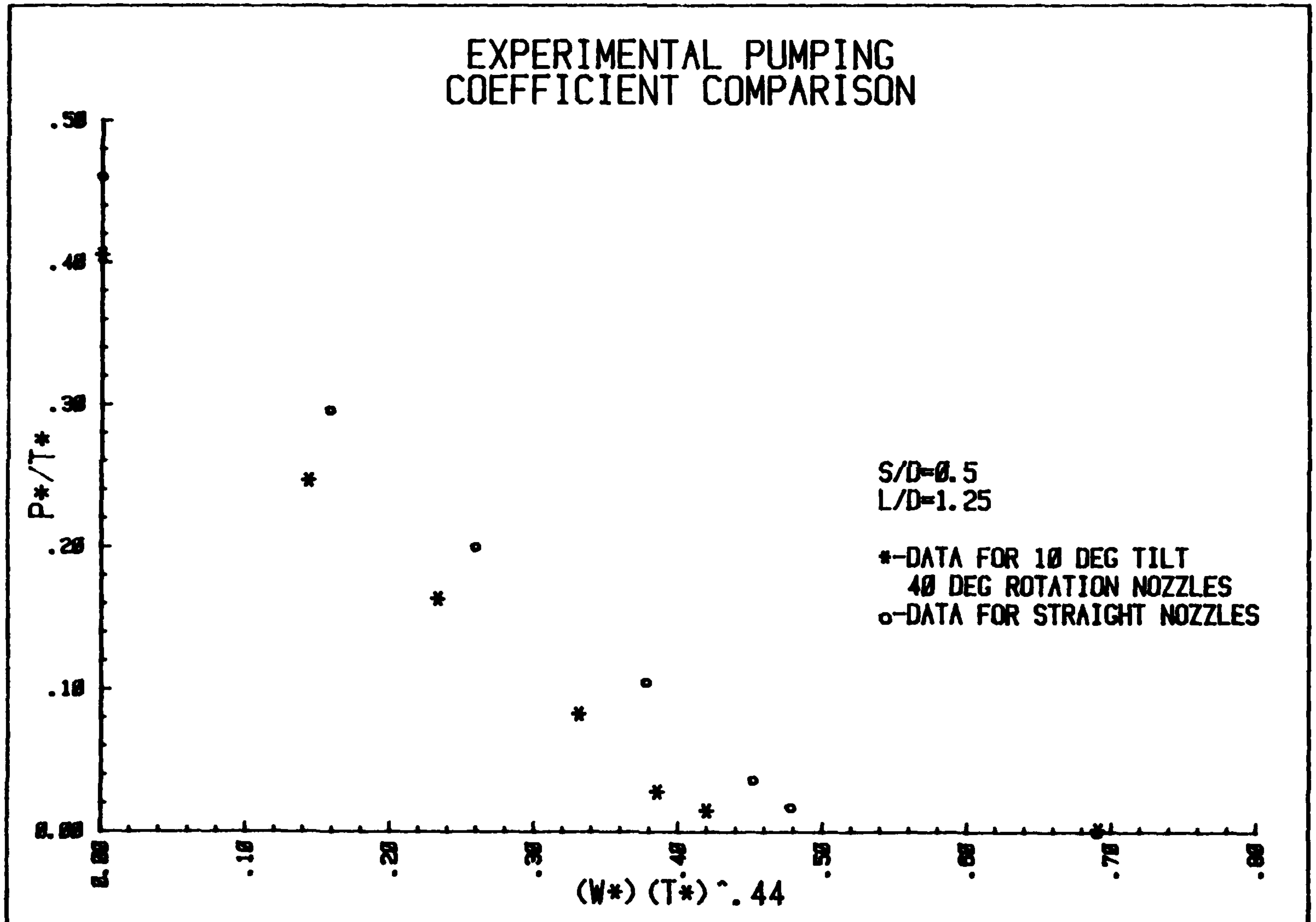
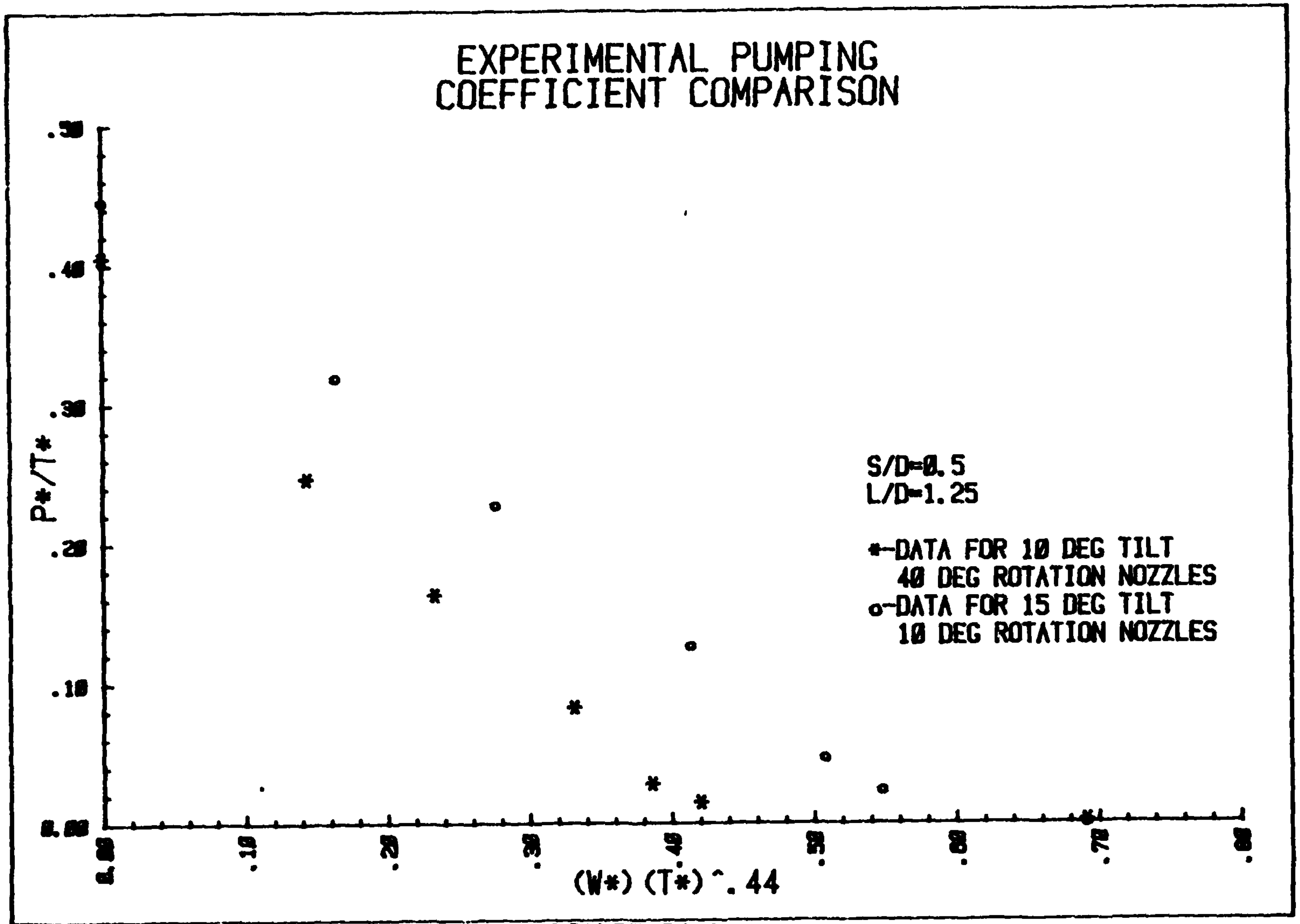

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE B3.1



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*)(T*)^.44

FIGURE 84


EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 10 DEG TILT
40 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*) (T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80
FIGURE 64.1

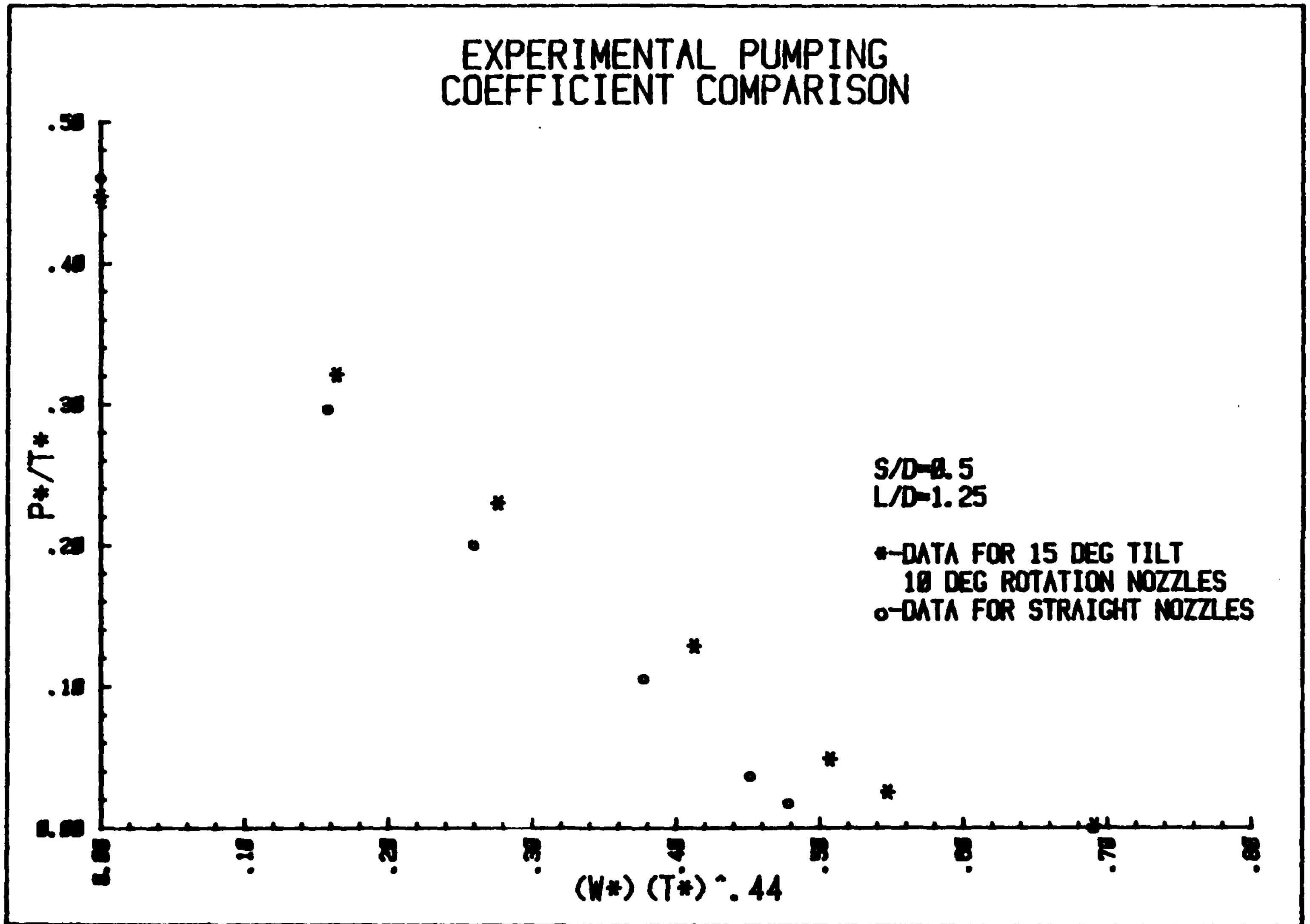

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
(W*) (T*)^.44
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 65

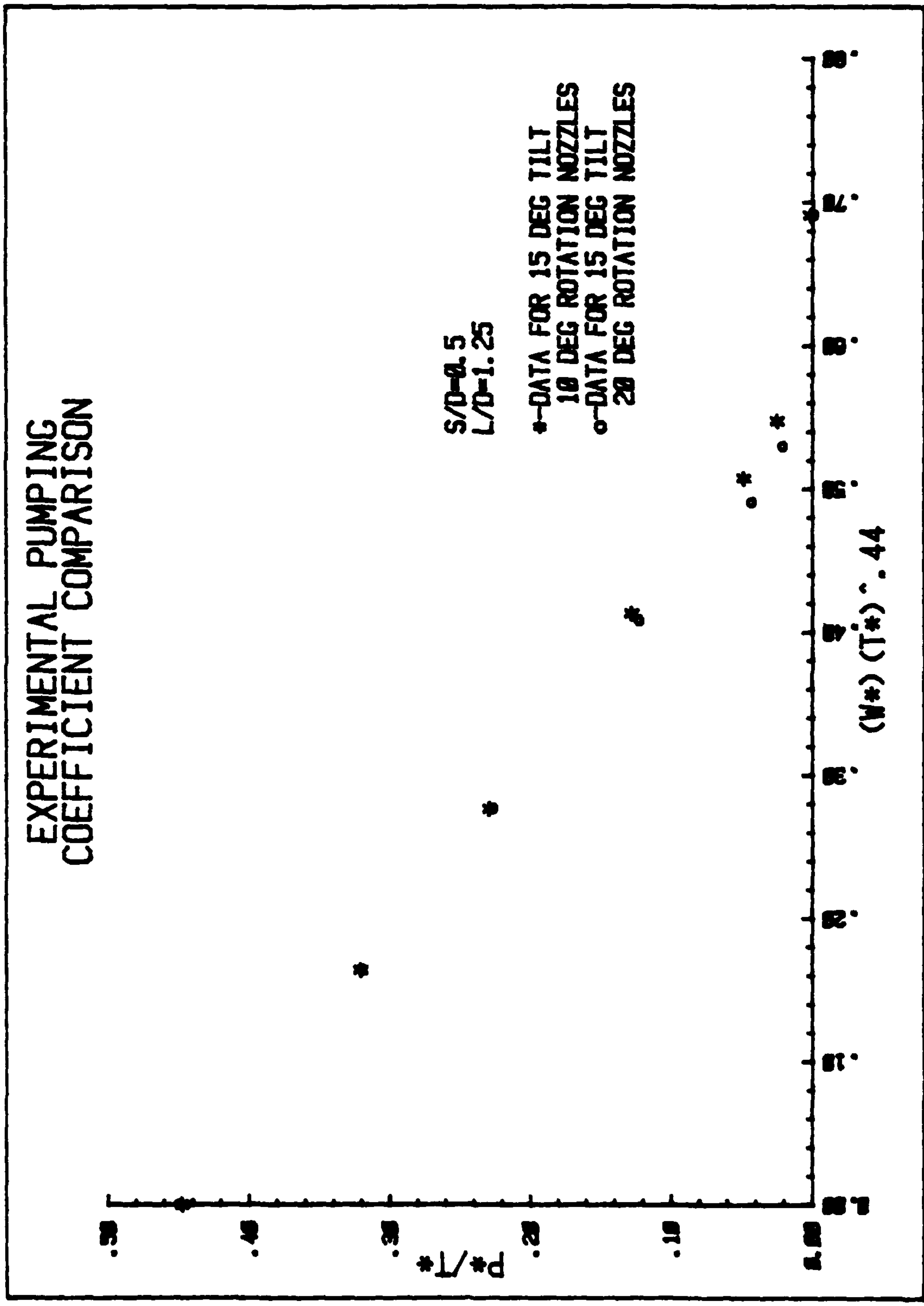

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 65.1

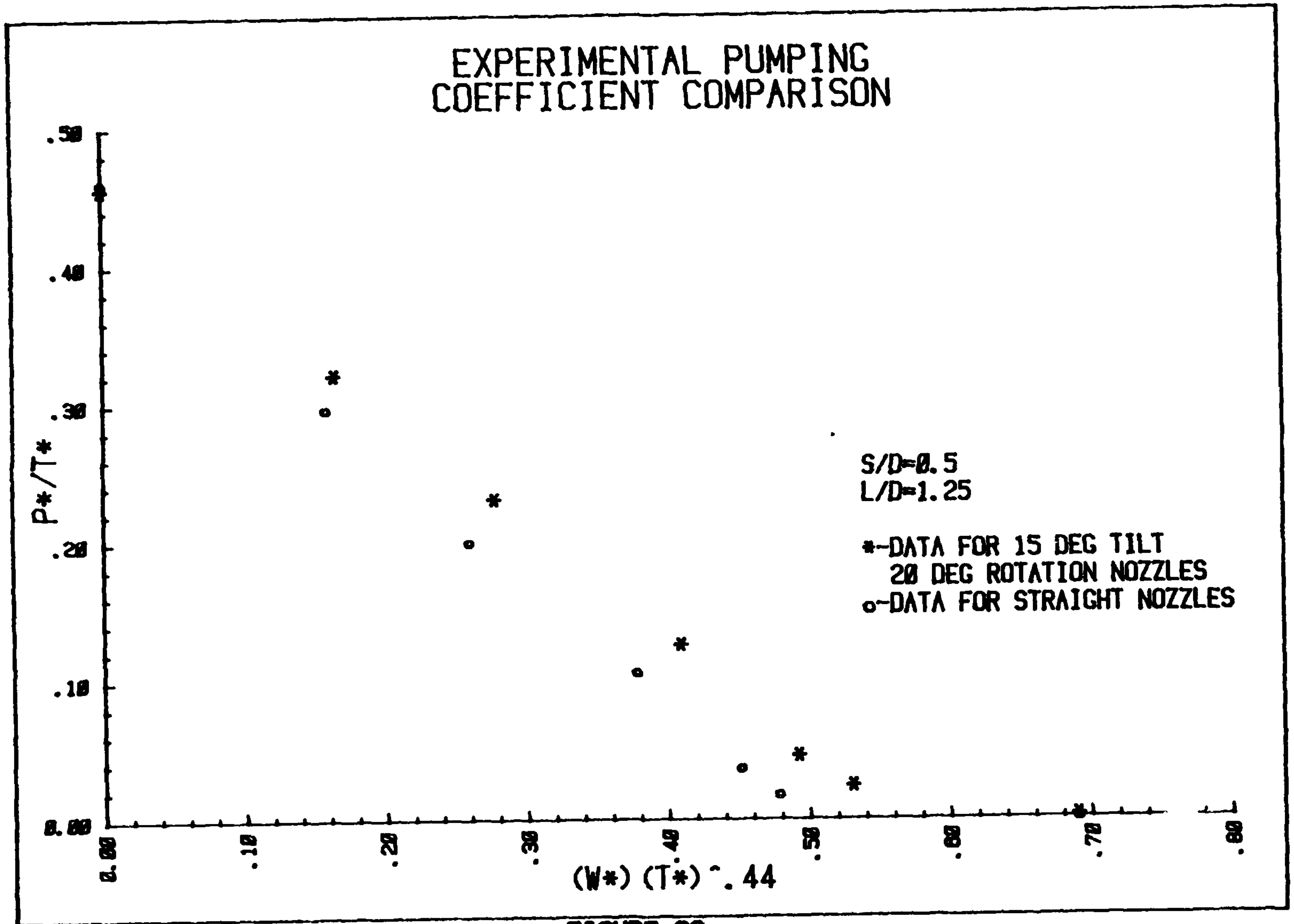

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 88

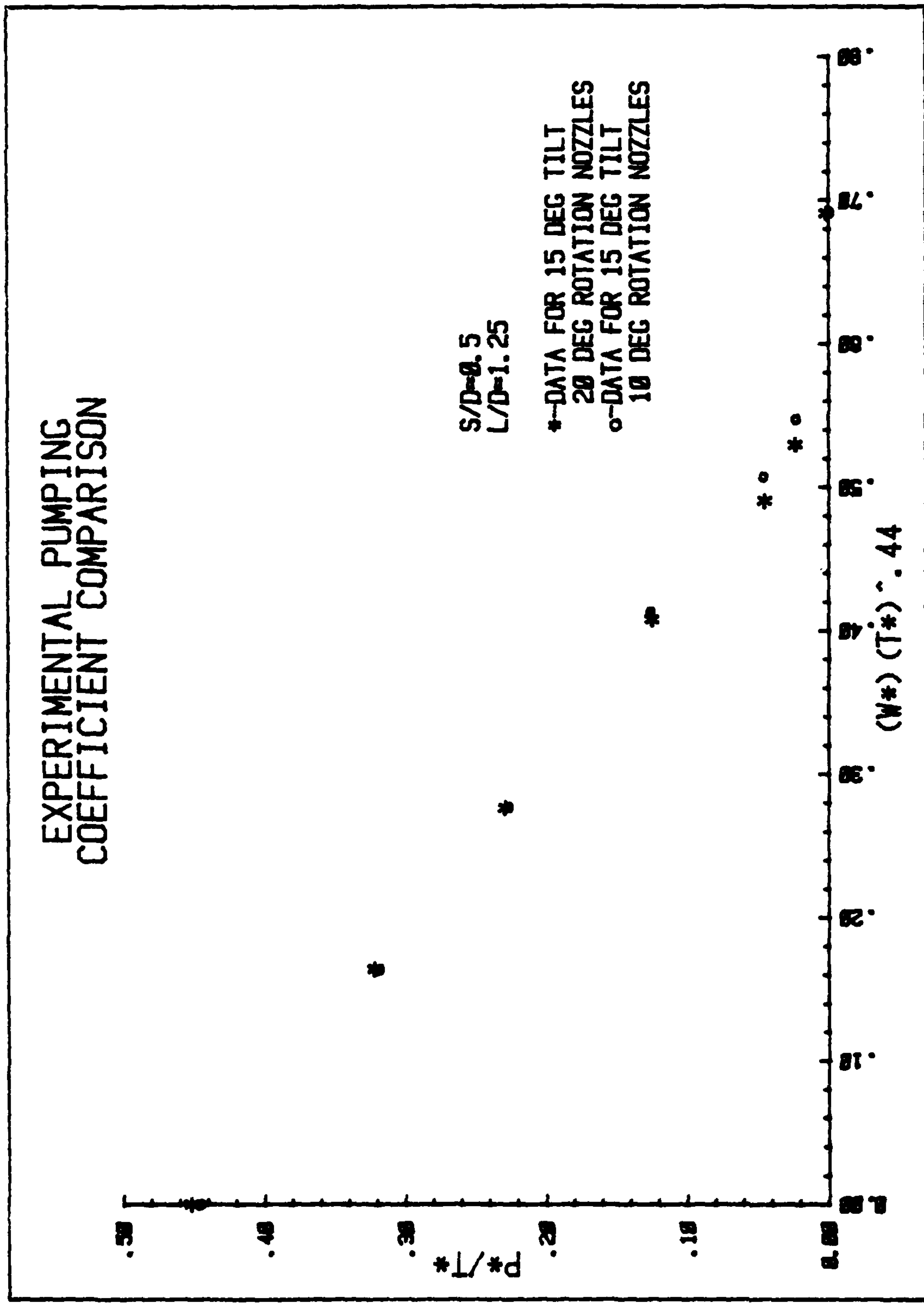
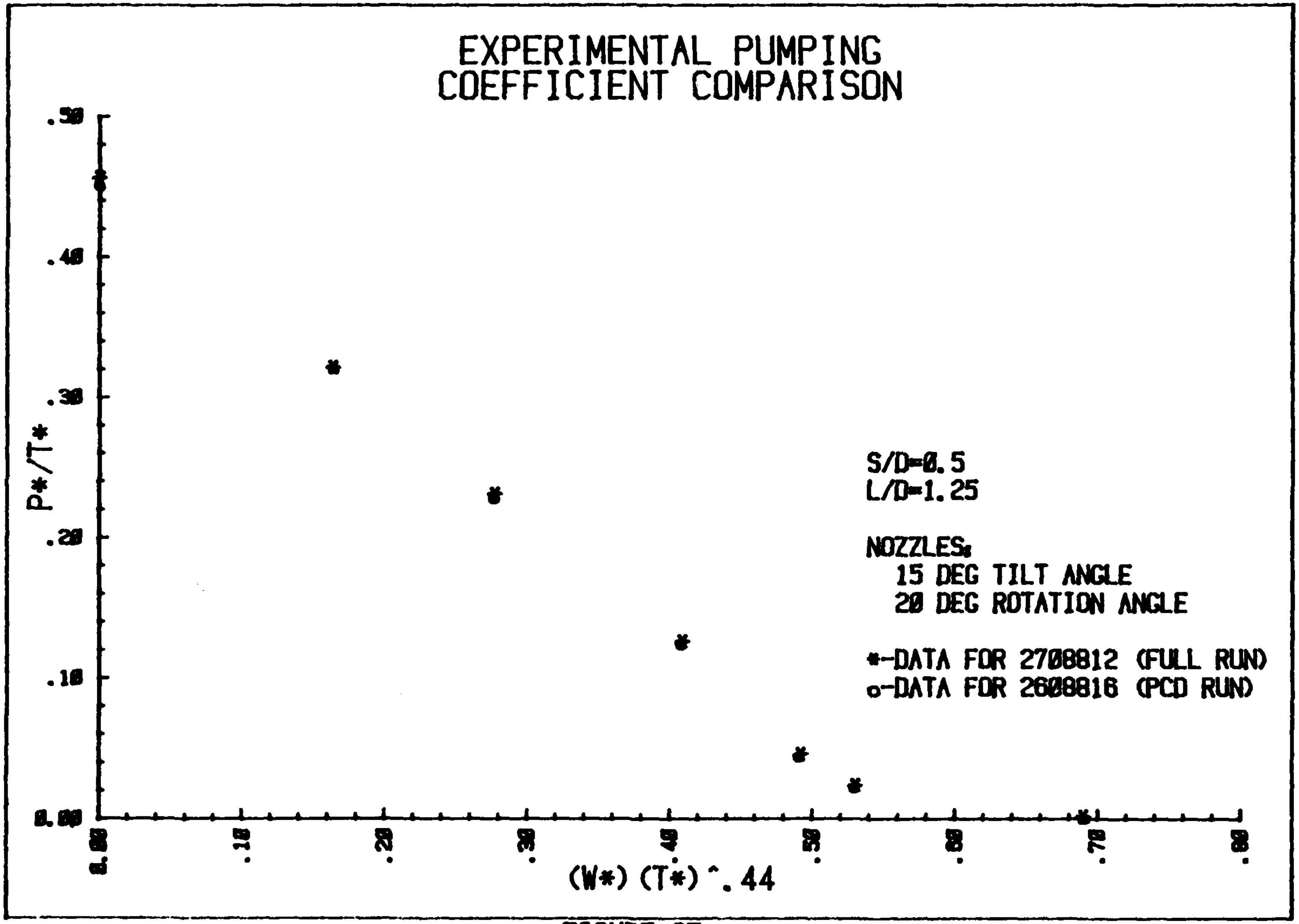
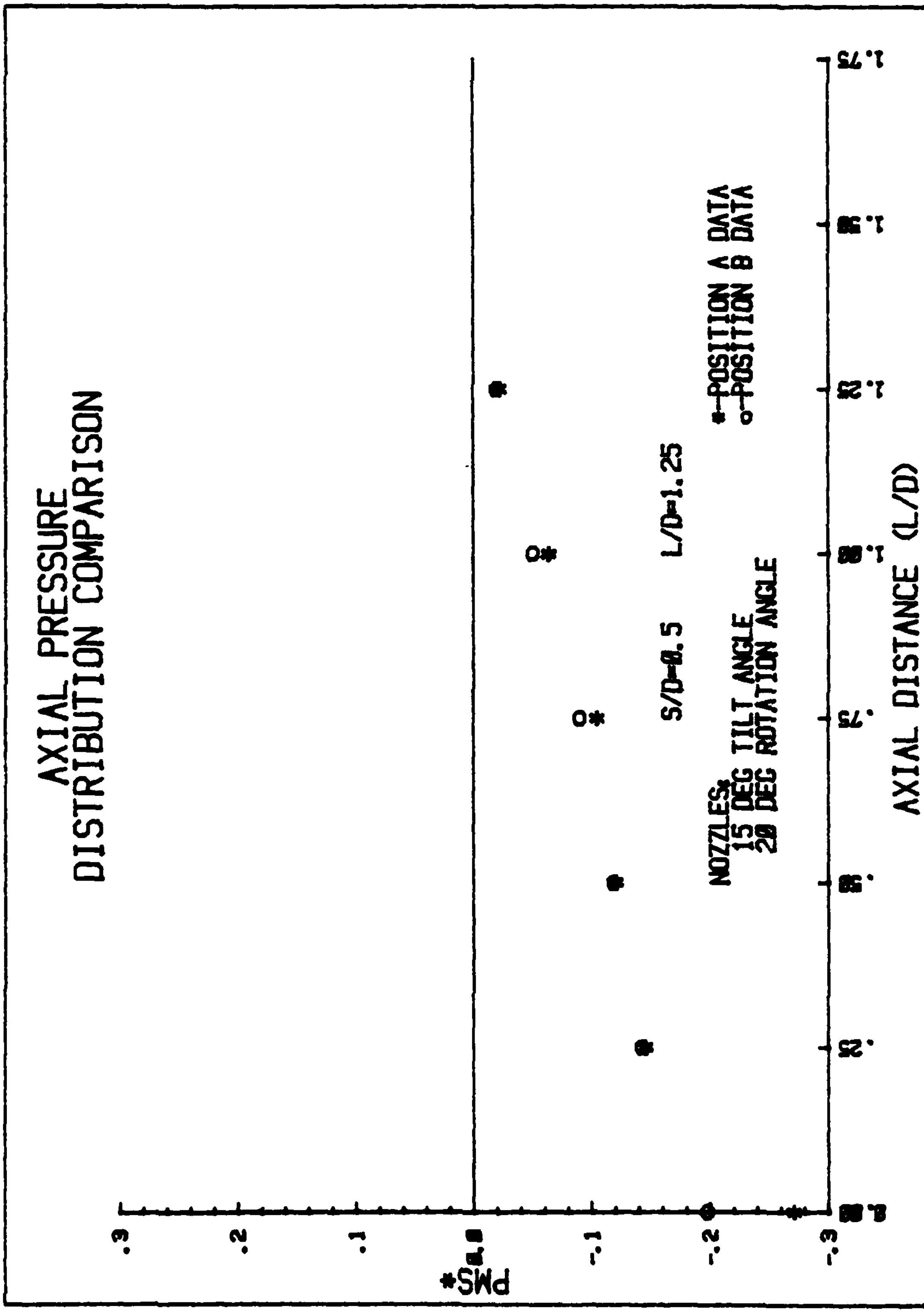

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 88.1



EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-DATA FOR 2708812 (FULL RUN)
o-DATA FOR 2608816 (PCD RUN)
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 67



AXIAL PRESSURE
DISTRIBUTION COMPARISON
S/D=0.5 L/D=1.25
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 67.1

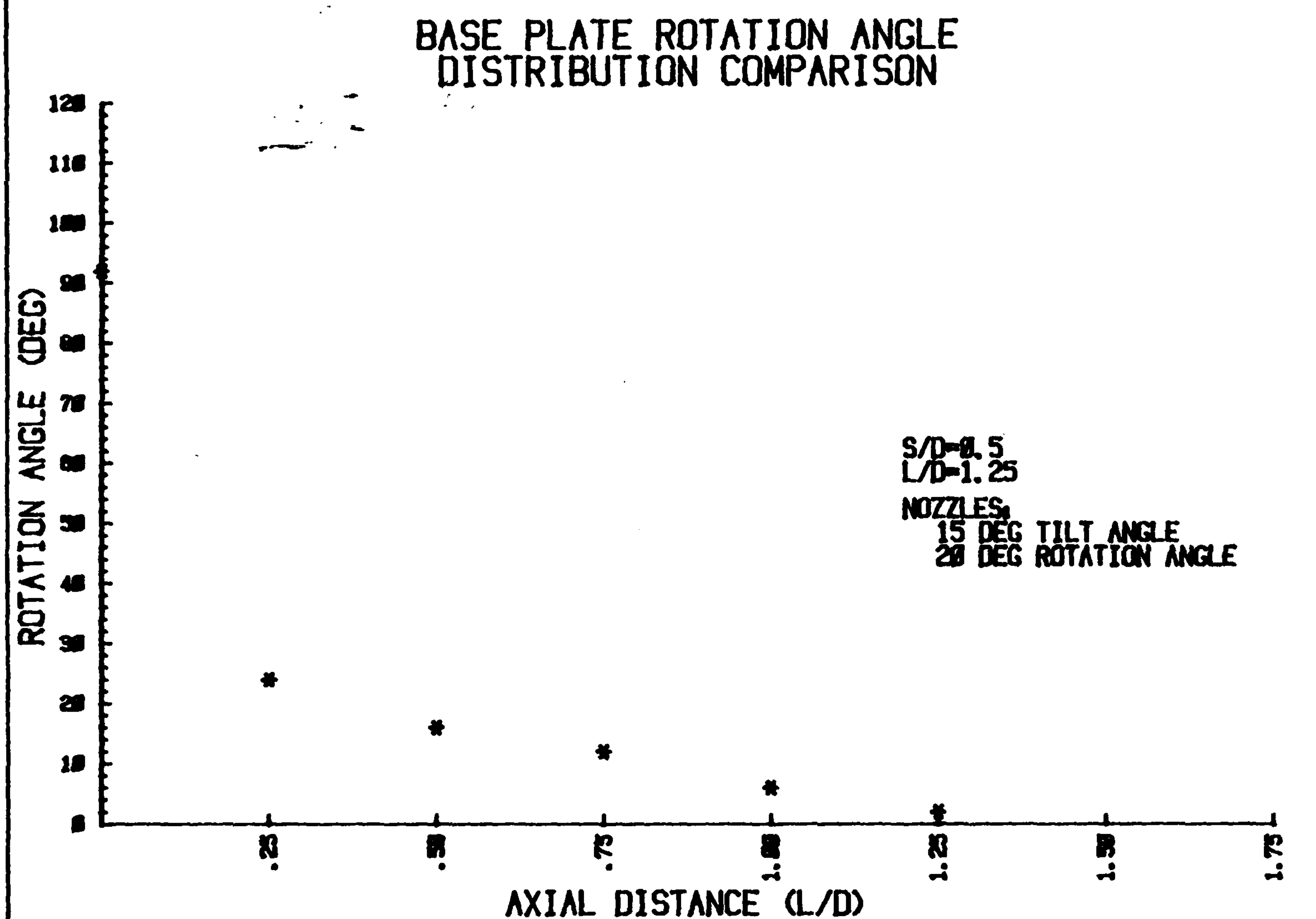

BASE PLATE ROTATION ANGLE
DISTRIBUTION COMPARISON
ROTATION ANGLE (DEG)
0
10
20
30
40
50
60
70
80
90
100
110
120
S/D=0.5
L/D=1.25
NOZZLES,
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 67.2

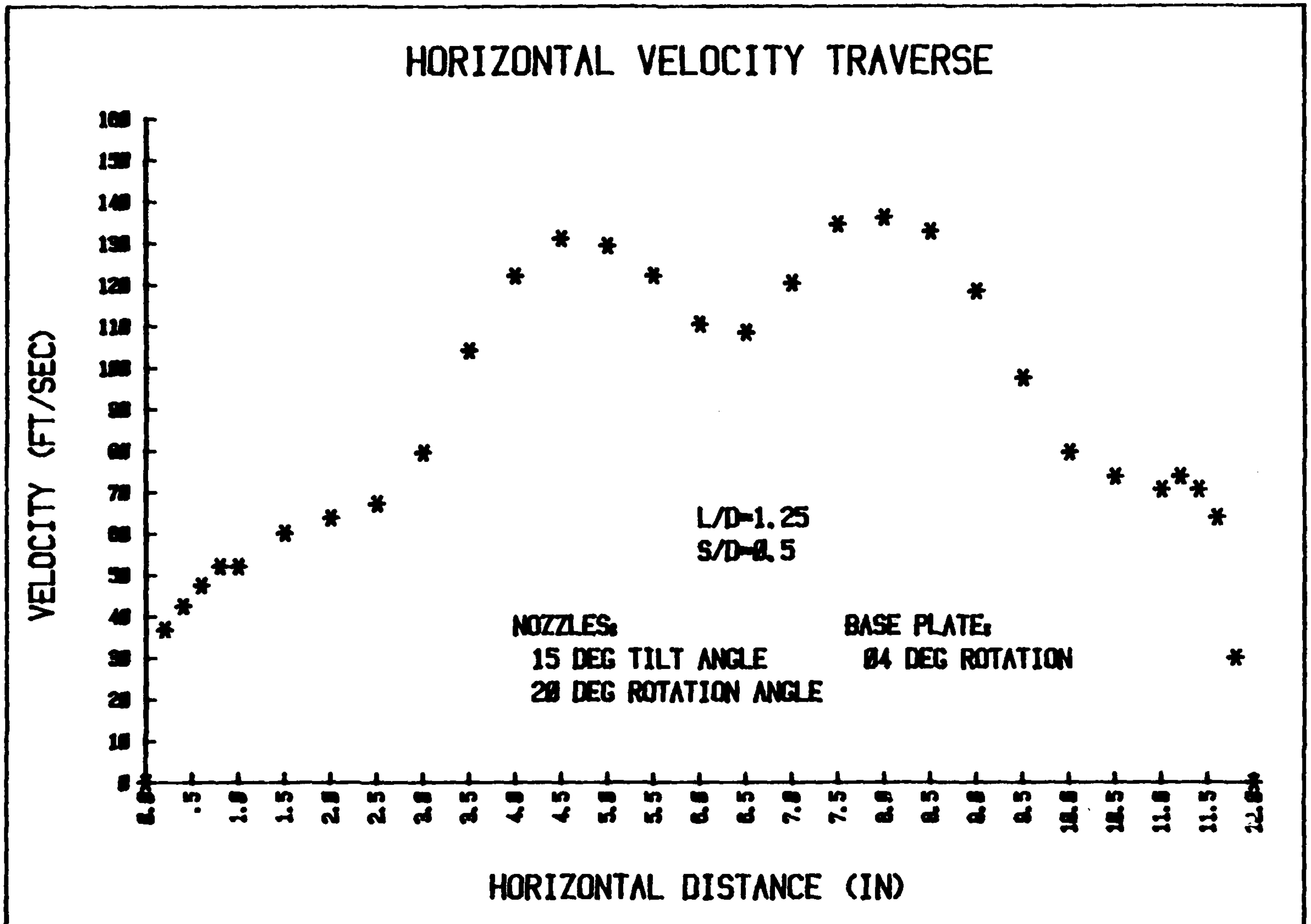

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
L/D=1.25
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
04 DEG ROTATION

FIGURE 67.3

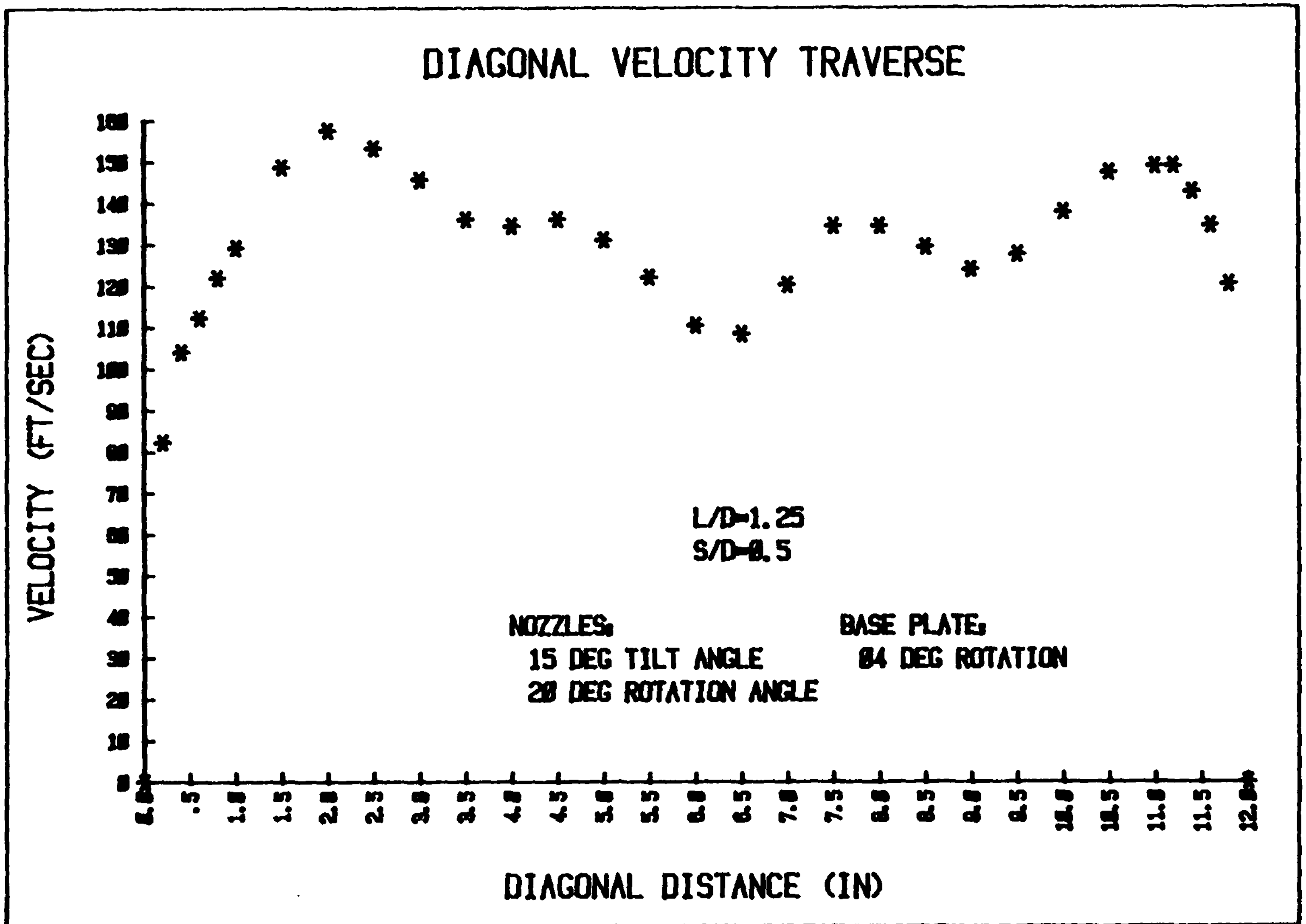

DIAGONAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
DIAGONAL DISTANCE (IN)
L/D=1.25
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
04 DEG ROTATION

FIGURE 67.4

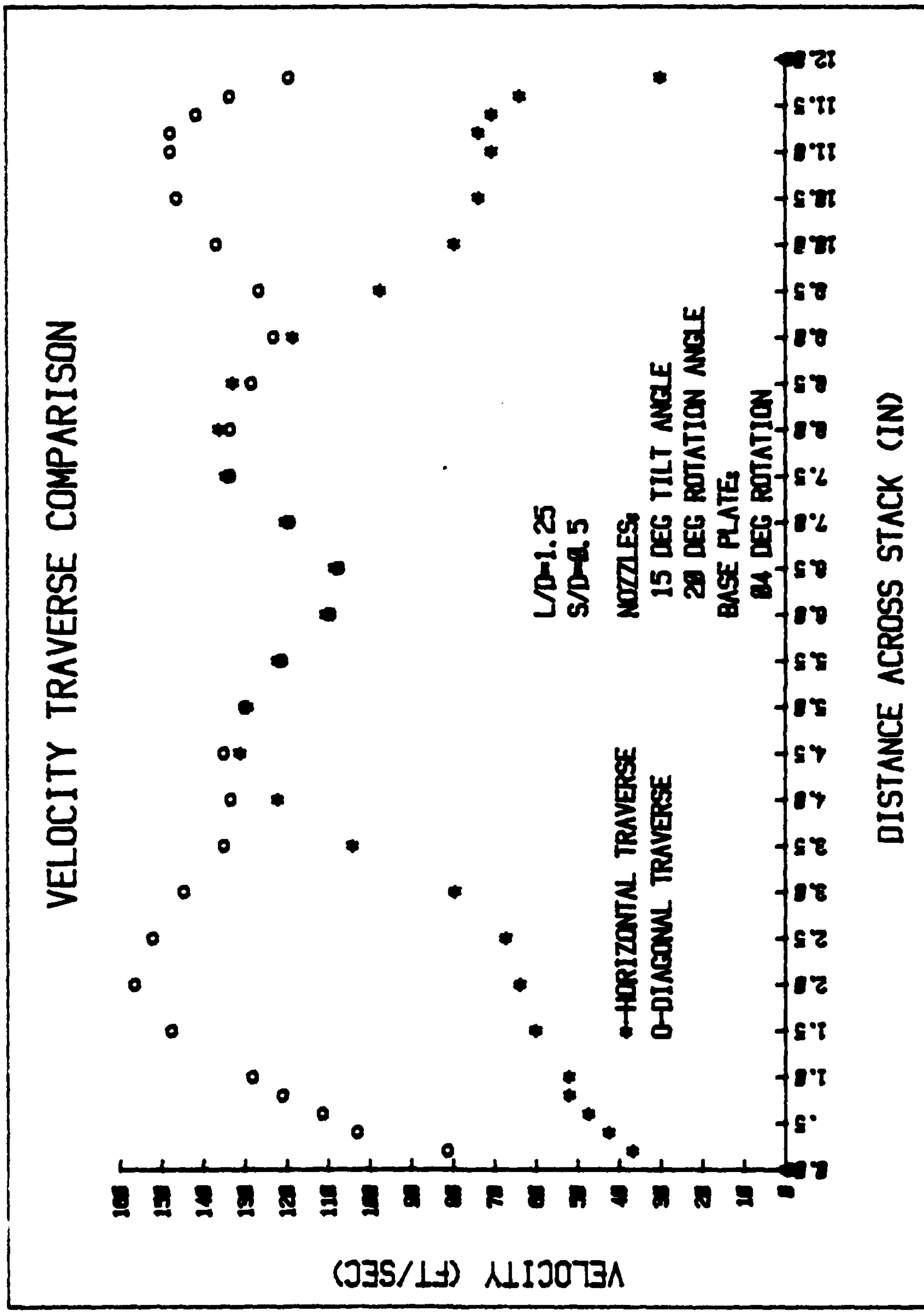

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.25
S/D=0.5
NOZZLES:
15 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
84 DEG ROTATION

FIGURE 67.5

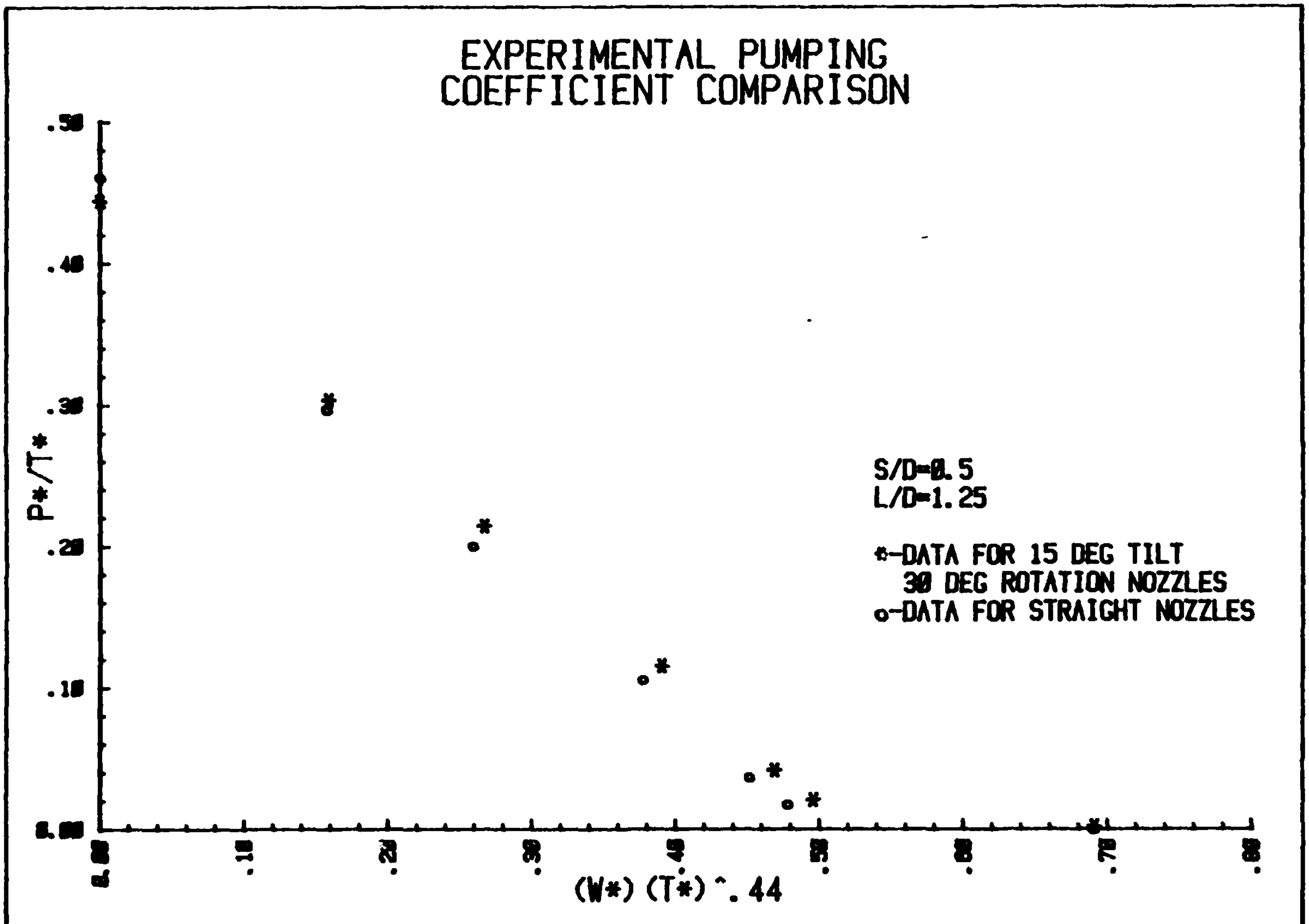

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 68

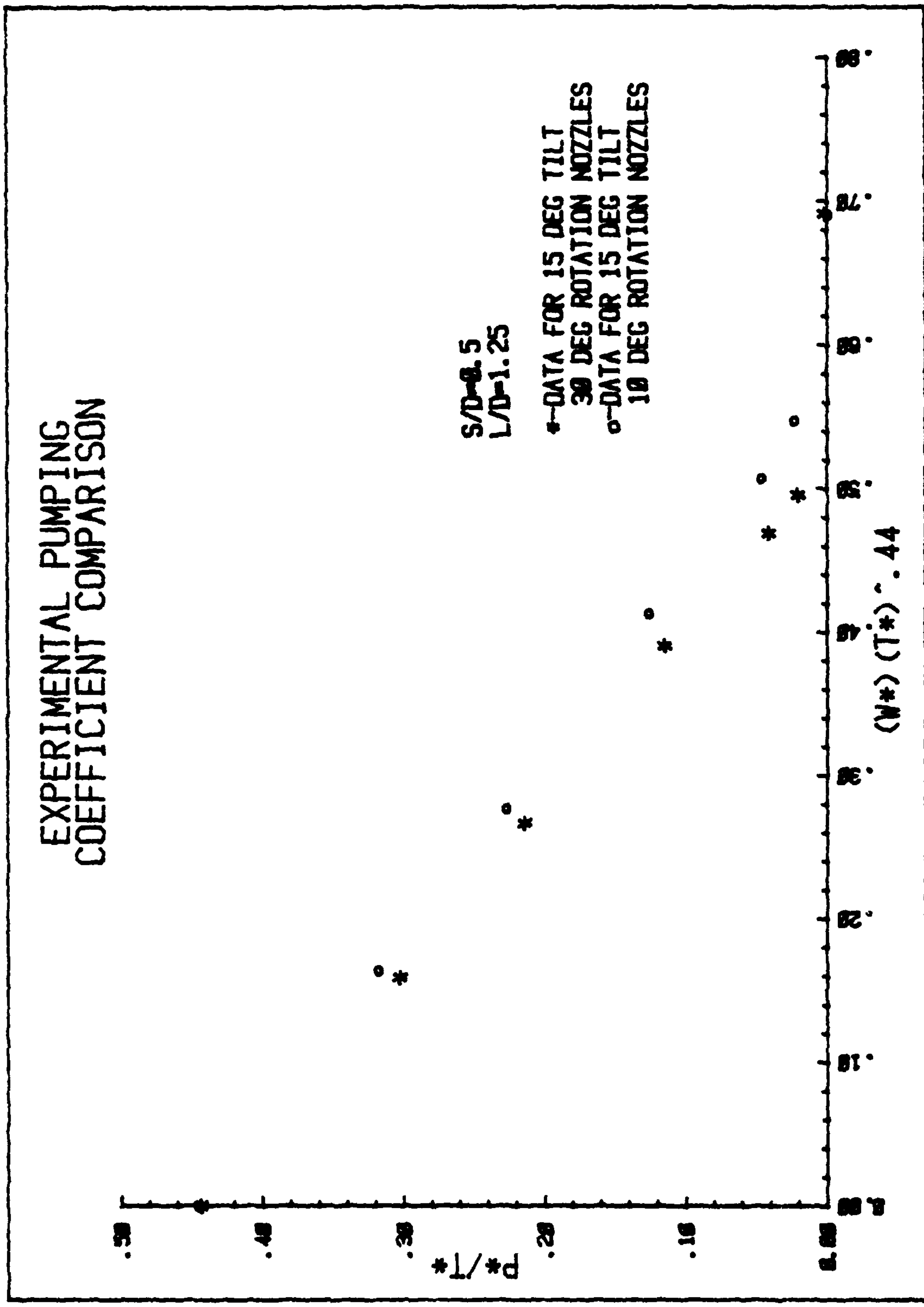

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 15 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 68.1

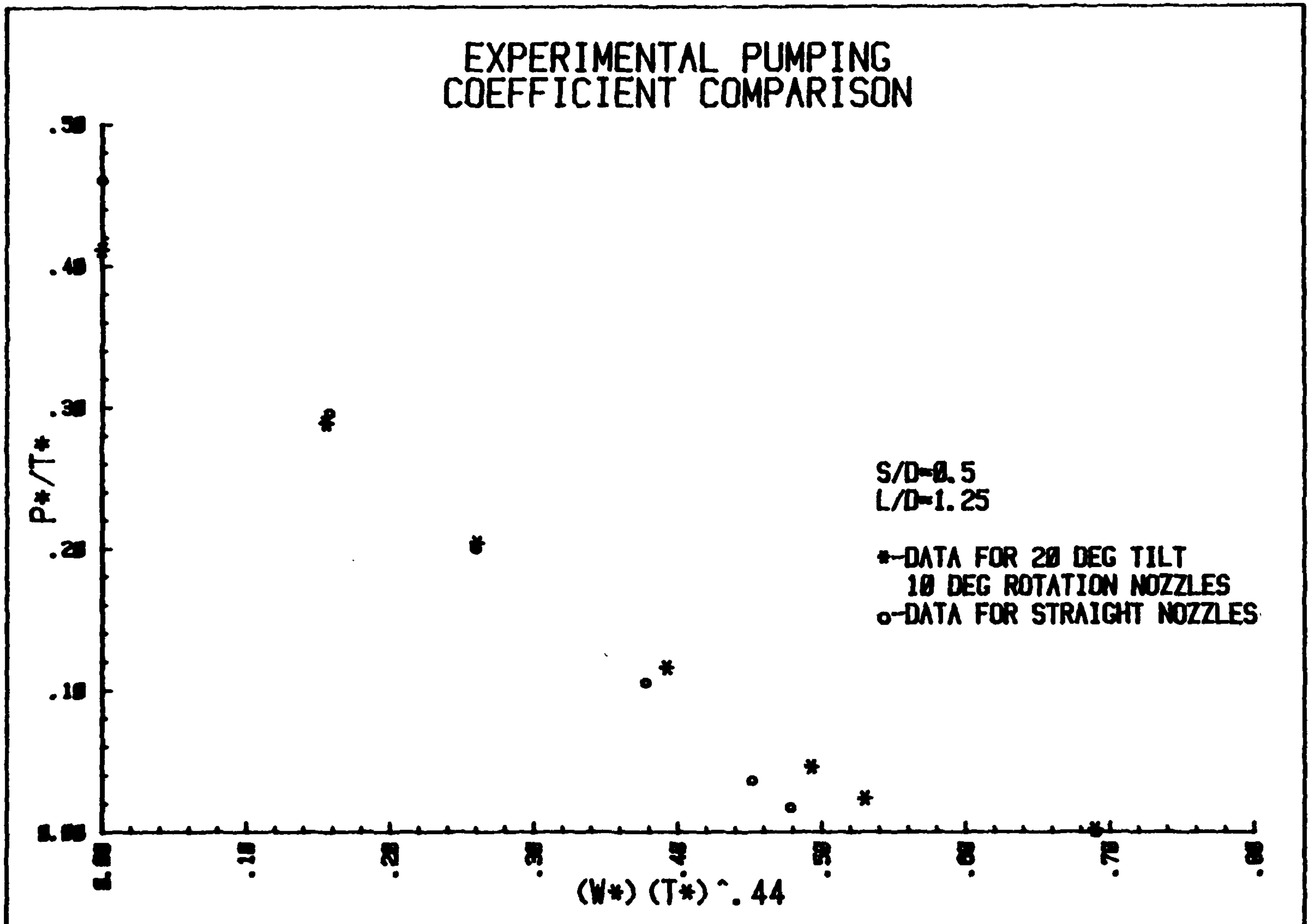

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*) (T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 69

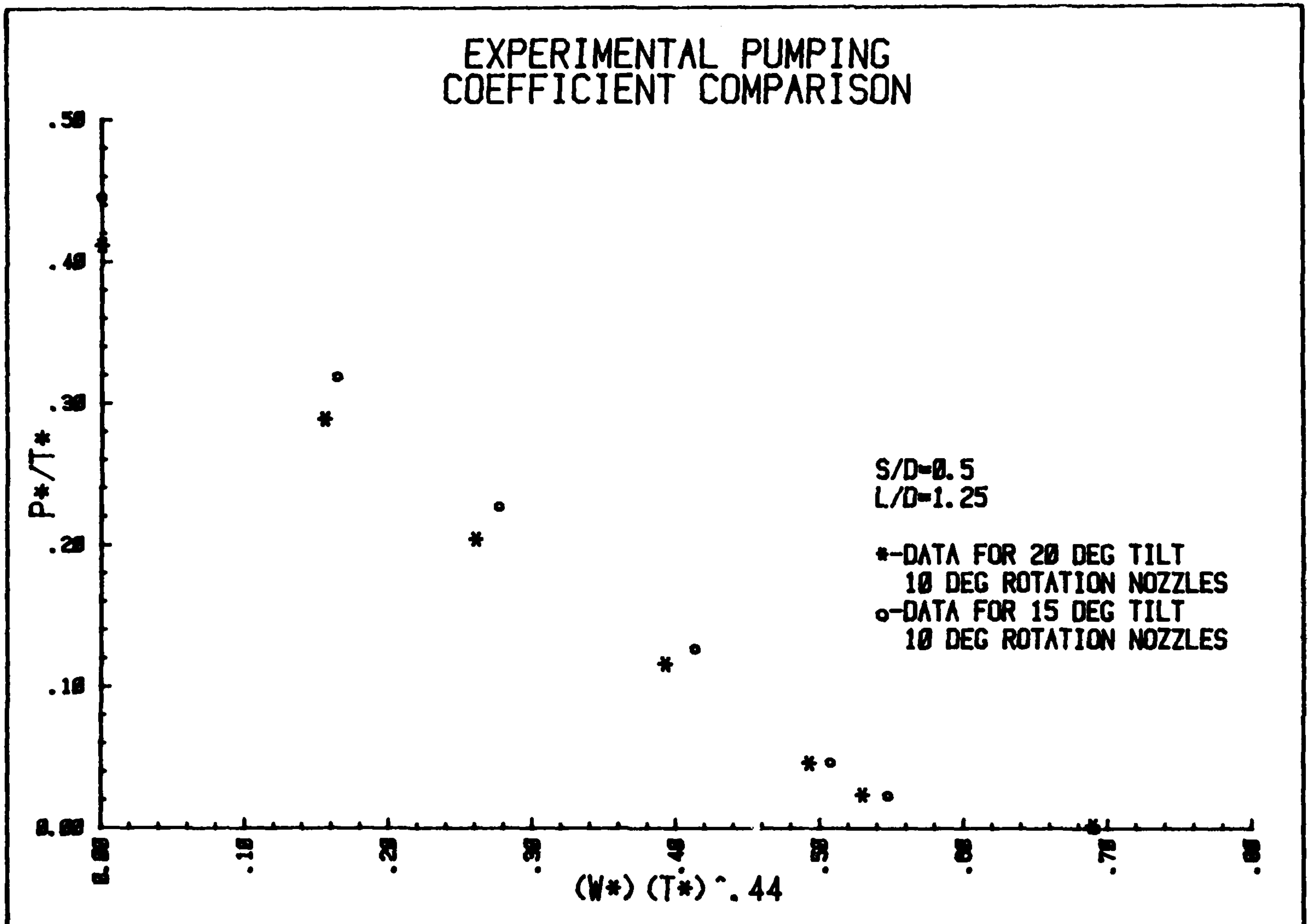

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 20 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*) (T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 69.1

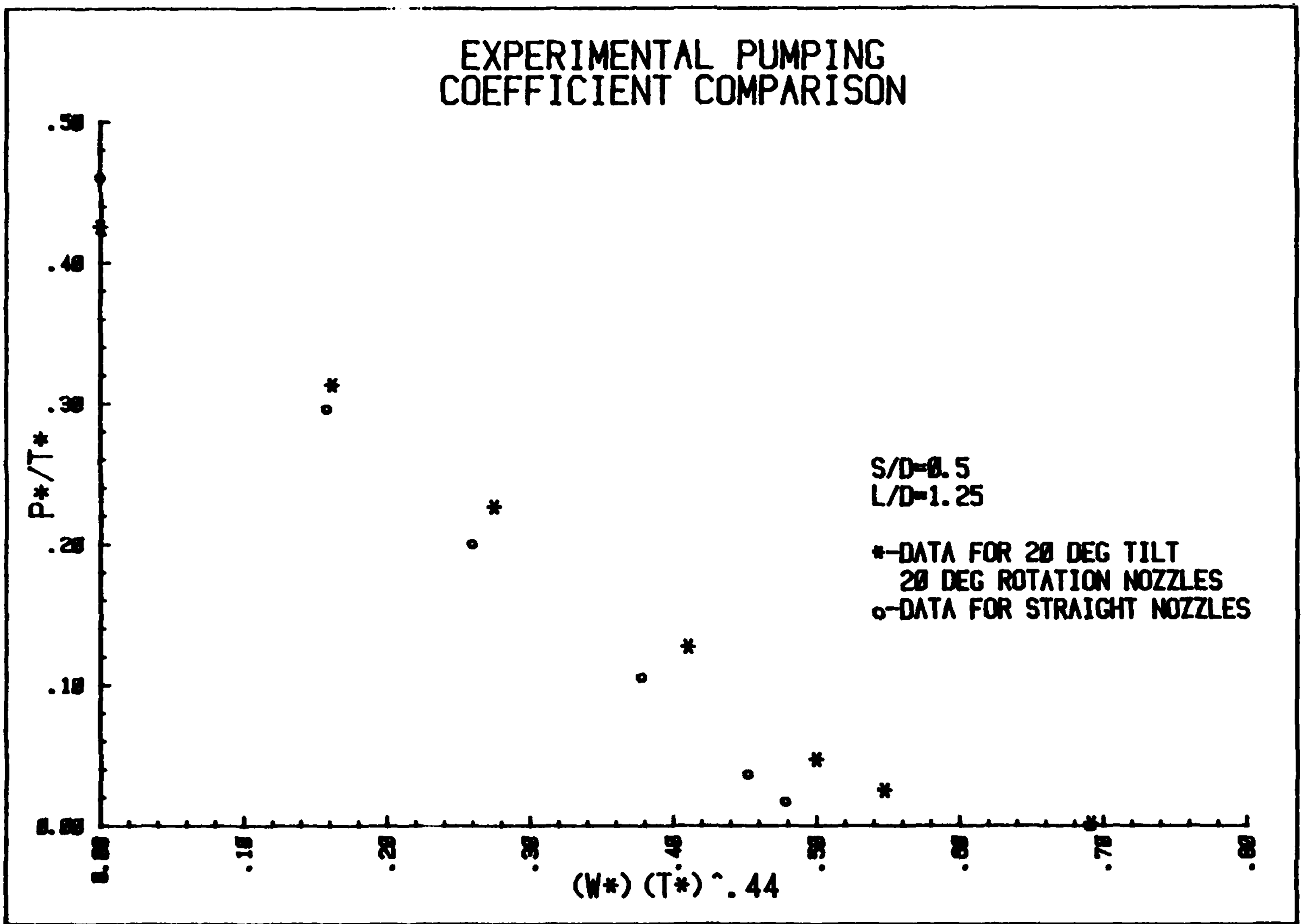

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 20 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44

FIGURE 70

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON

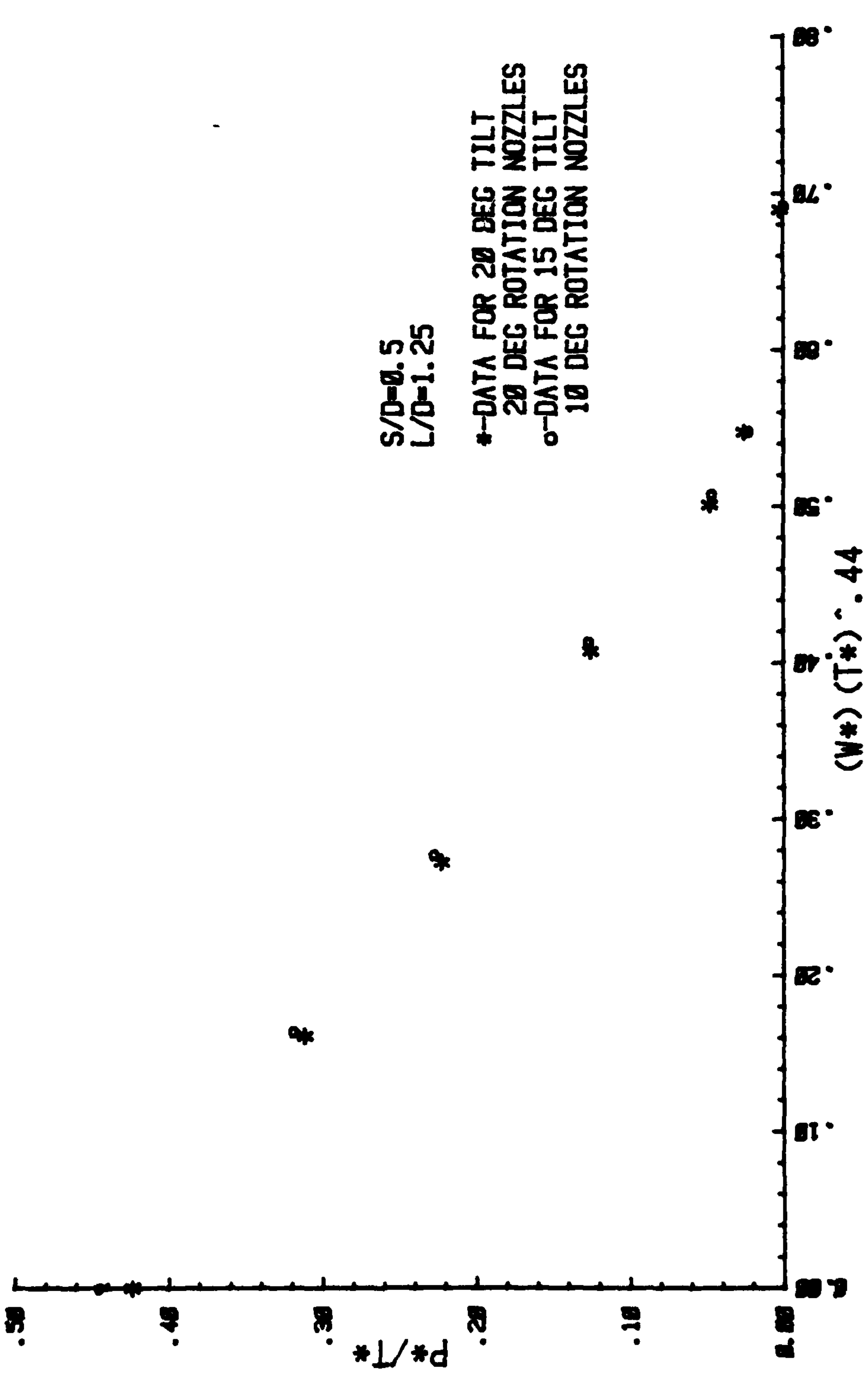


FIGURE 70.1

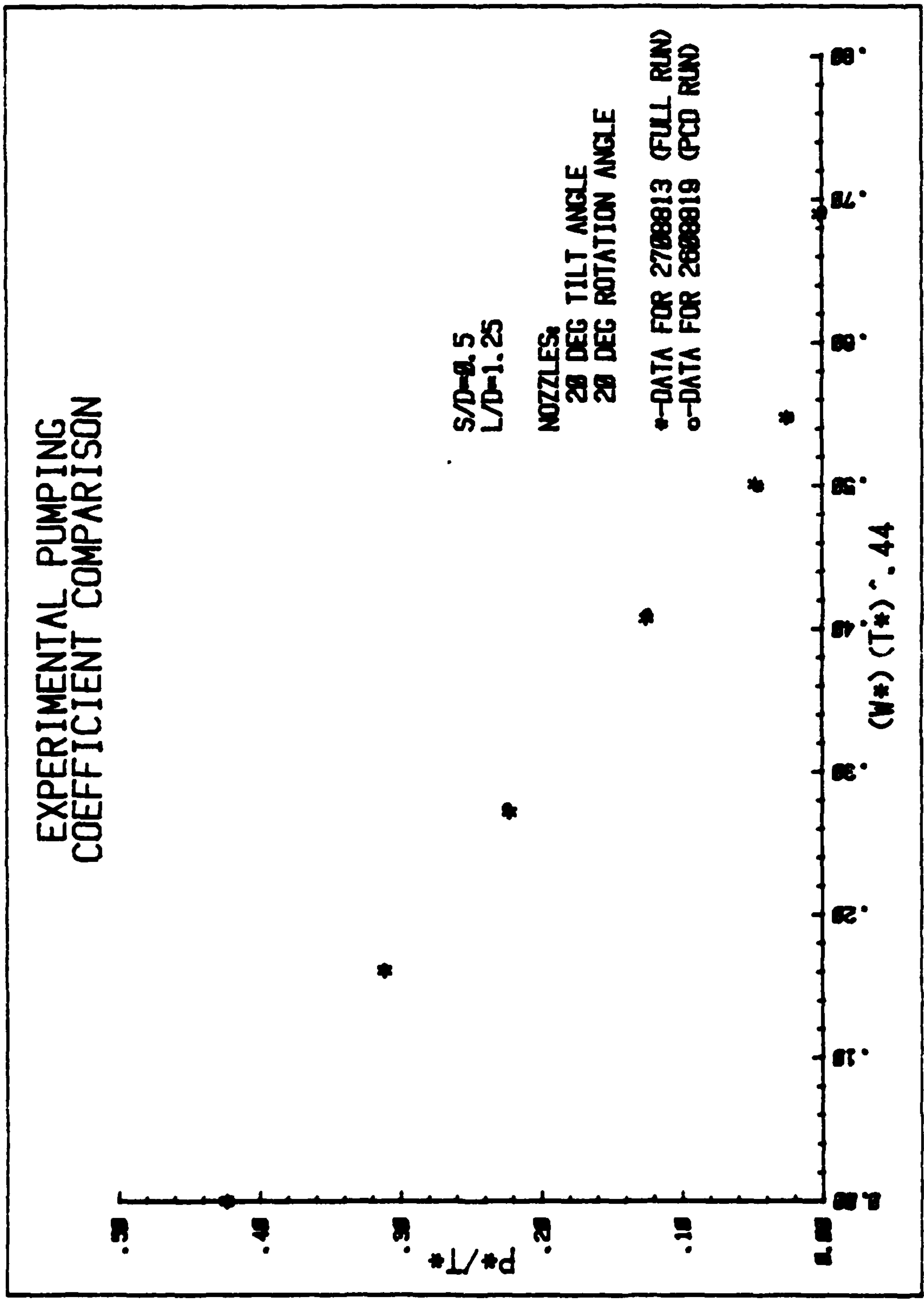

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-DATA FOR 2700813 (FULL RUN)
o-DATA FOR 2600819 (PCD RUN)
P*/T*
0.00
.10
.20
.30
.40
.50
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 71

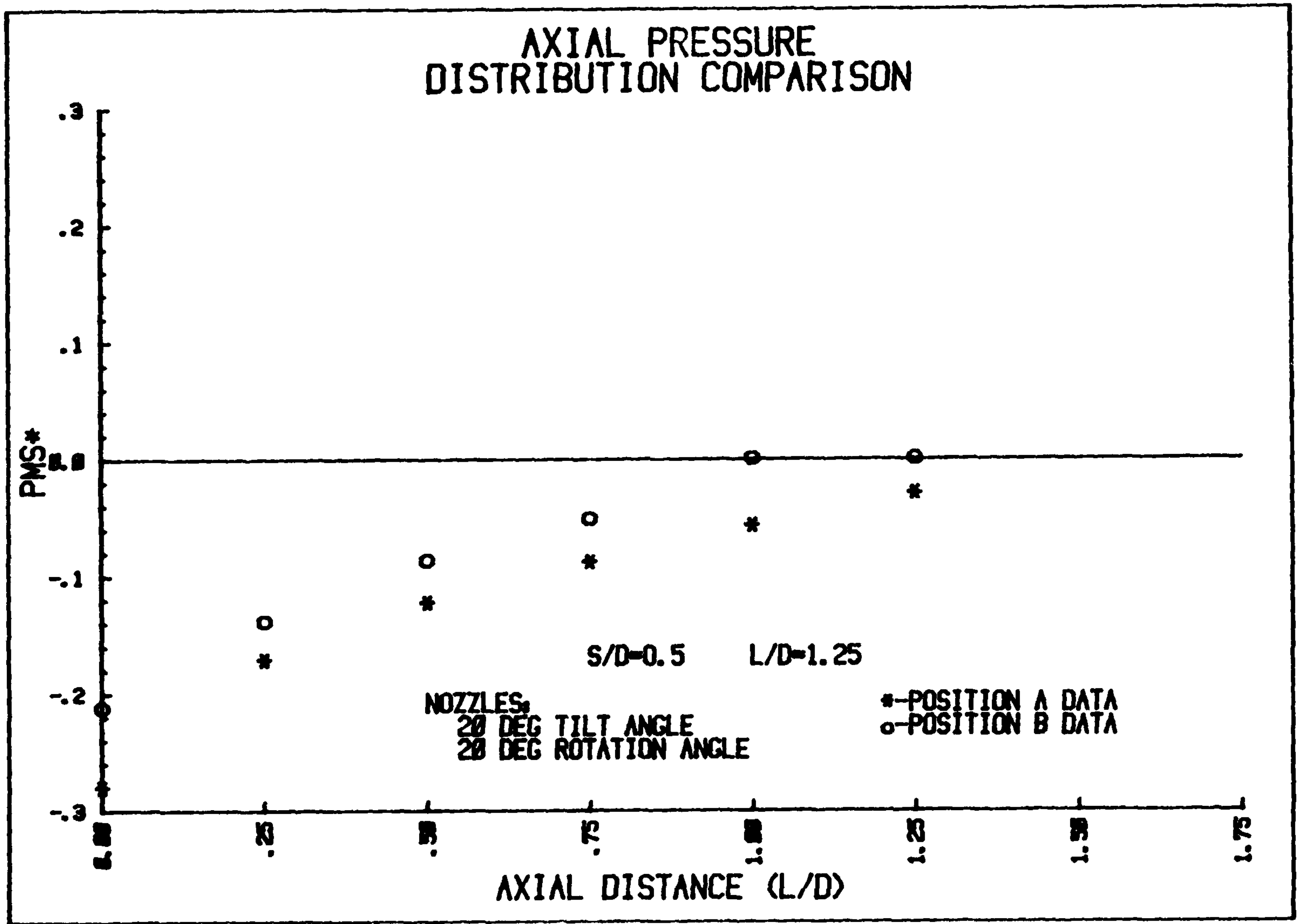

AXIAL PRESSURE
DISTRIBUTION COMPARISON
PMS*
.3
.2
.1
0.0
-.1
-.2
-.3
S/D=0.5 L/D=1.25
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
*-POSITION A DATA
o-POSITION B DATA
0.00
.25
.50
.75
1.00
1.25
1.50
1.75
AXIAL DISTANCE (L/D)

FIGURE 71.1

BASE PLATE ROTATION ANGLE DISTRIBUTION COMPARISON

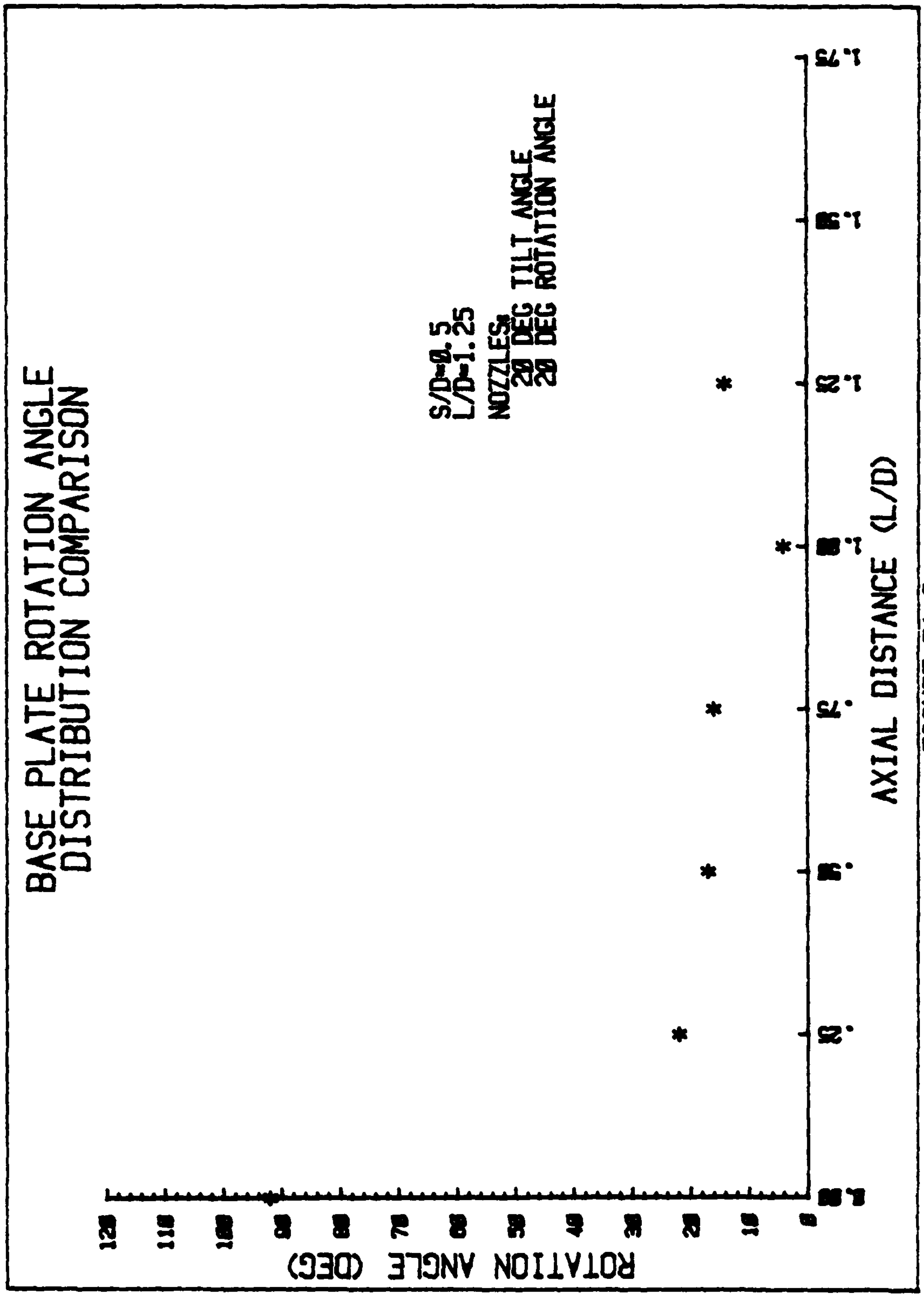


FIGURE 71.2

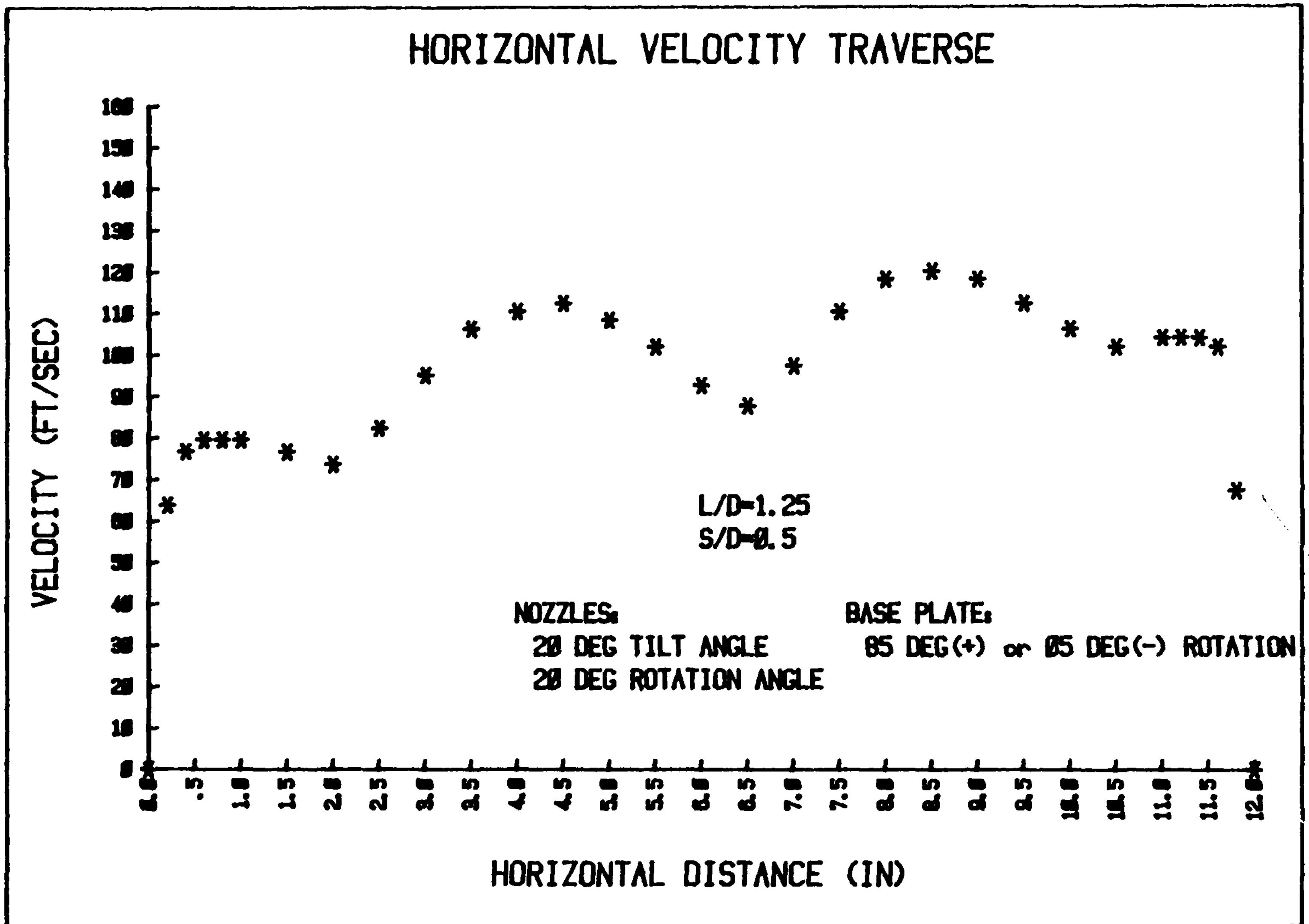

HORIZONTAL VELOCITY TRAVERSE
VELOCITY (FT/SEC)
HORIZONTAL DISTANCE (IN)
L/D=1.25
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
05 DEG(+) or 05 DEG(-) ROTATION

FIGURE 71.3

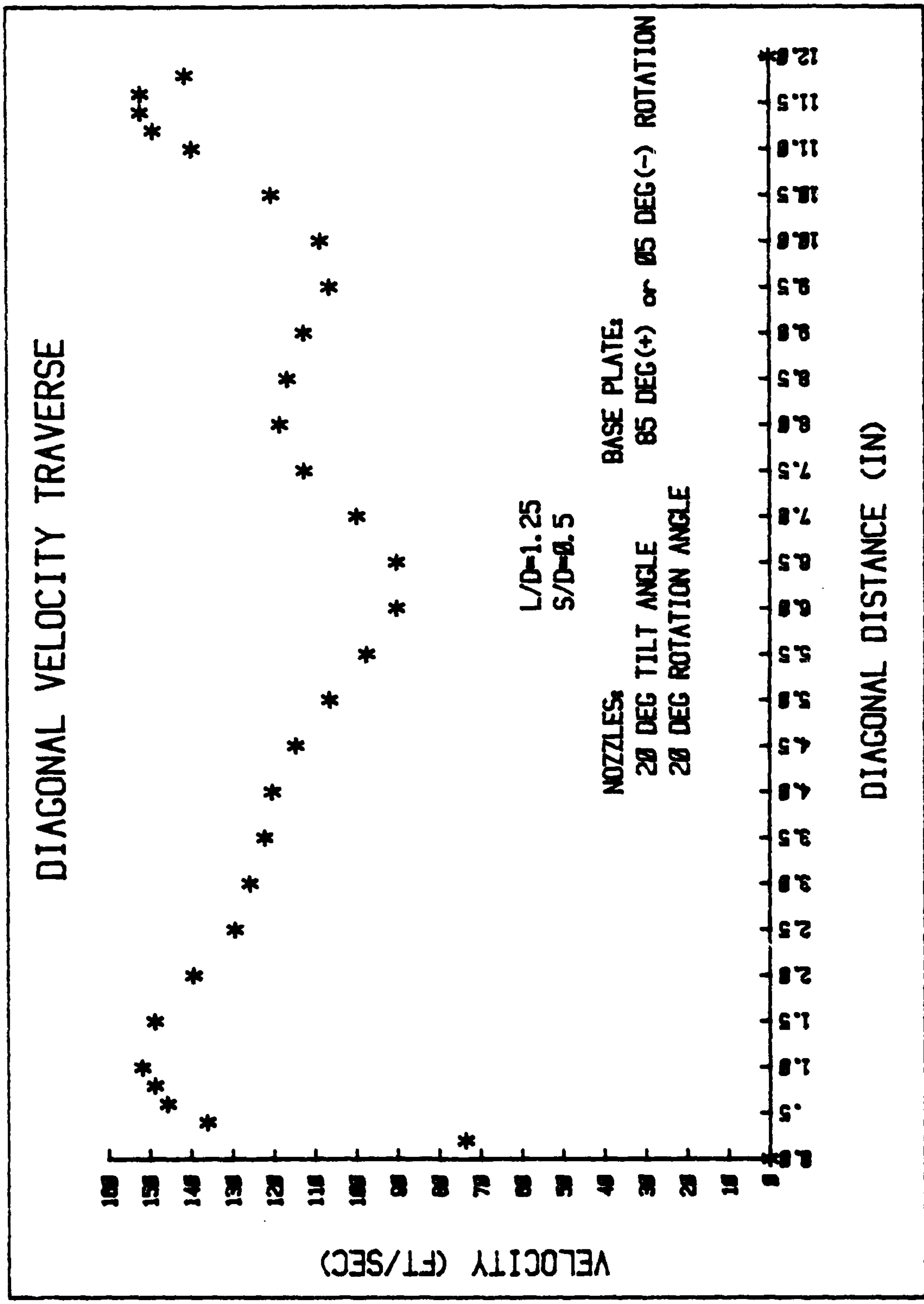

DIAGONAL VELOCITY TRAVERSE
L/D=1.25
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
05 DEG(+) or 05 DEG(-) ROTATION
DIAGONAL DISTANCE (IN)
VELOCITY (FT/SEC)

FIGURE 71.4

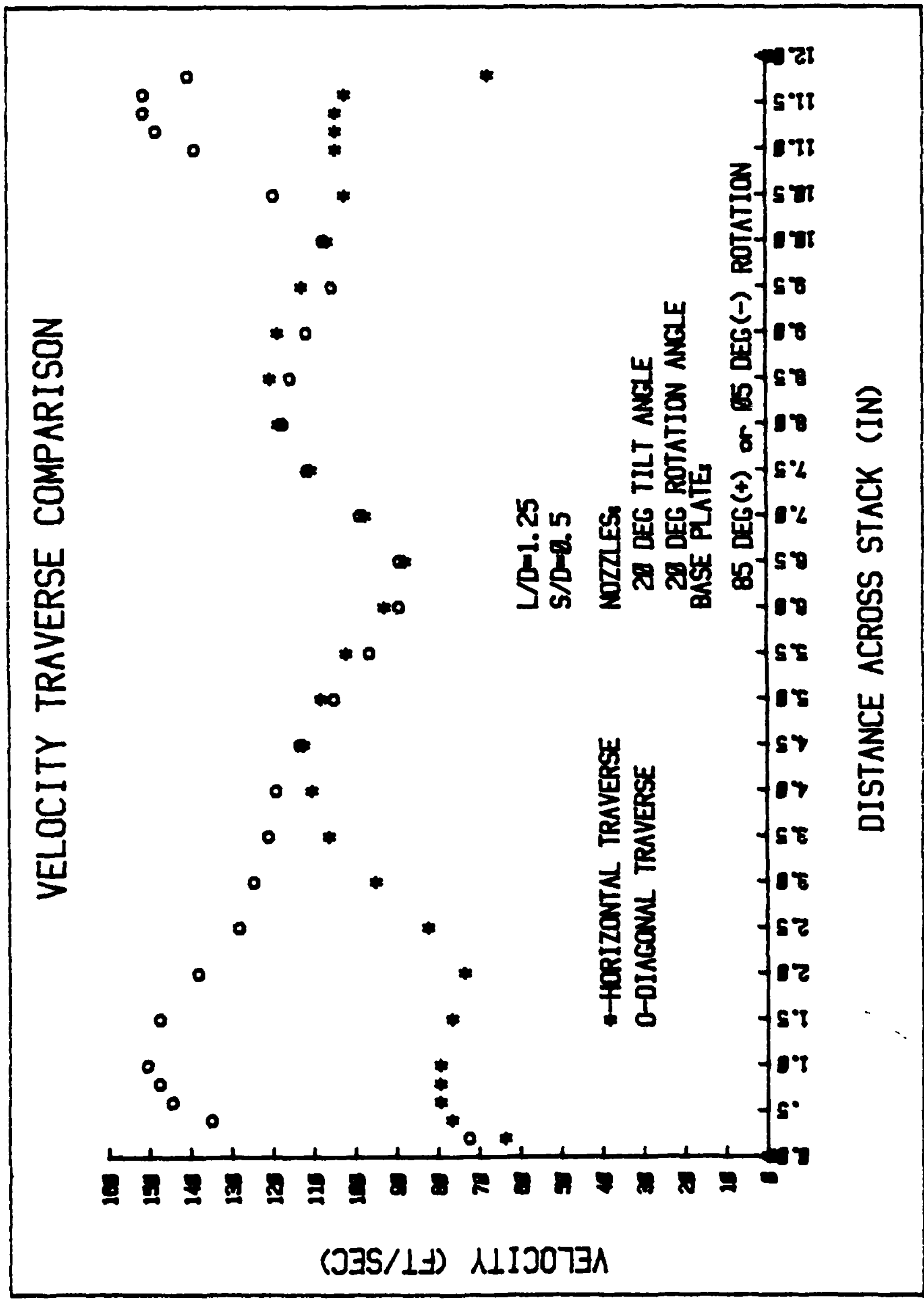

VELOCITY TRAVERSE COMPARISON
VELOCITY (FT/SEC)
DISTANCE ACROSS STACK (IN)
*-HORIZONTAL TRAVERSE
O-DIAGONAL TRAVERSE
L/D=1.25
S/D=0.5
NOZZLES:
20 DEG TILT ANGLE
20 DEG ROTATION ANGLE
BASE PLATE:
05 DEG(+) or 05 DEG(-) ROTATION

FIGURE 71.5

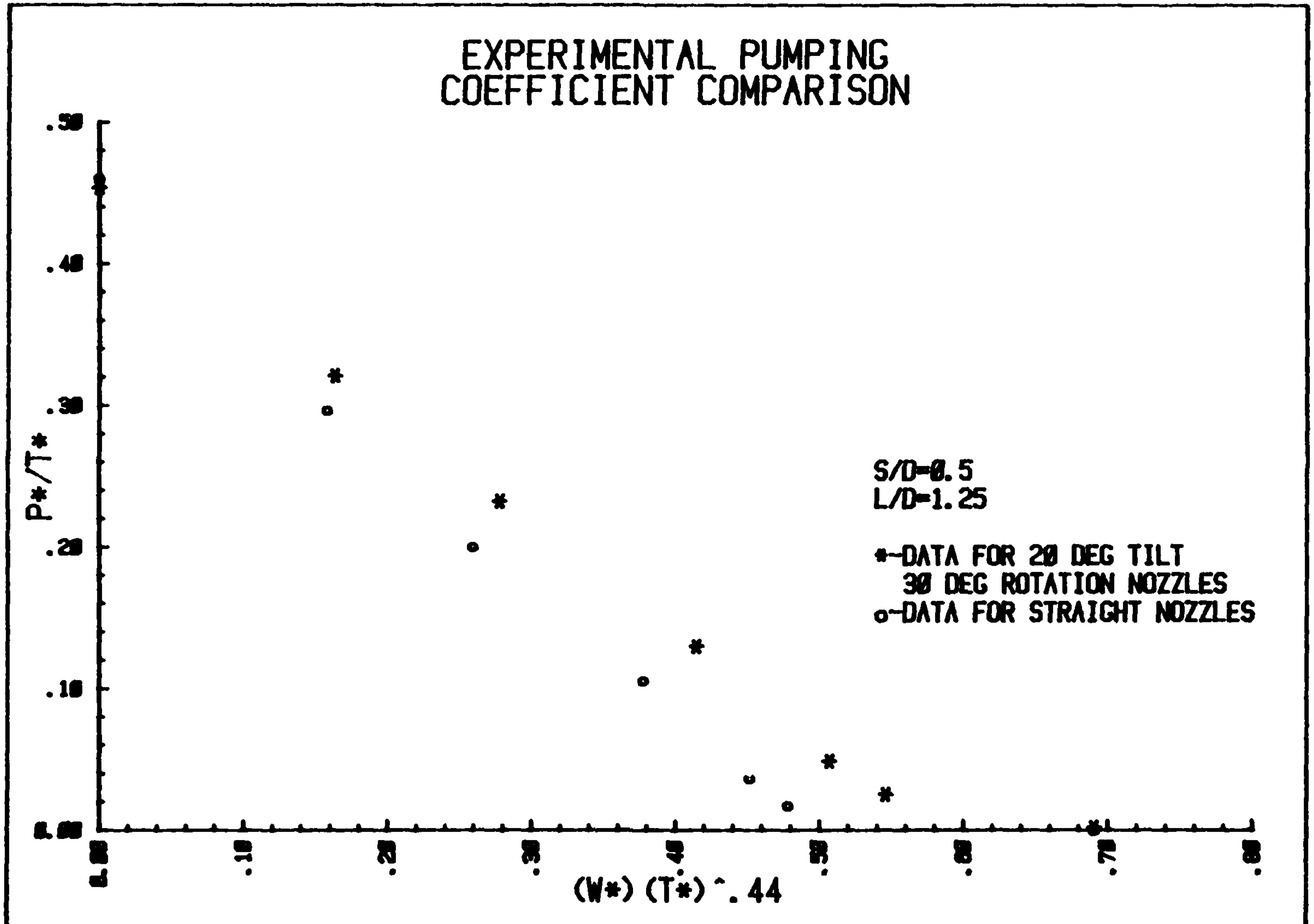

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 20 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 72

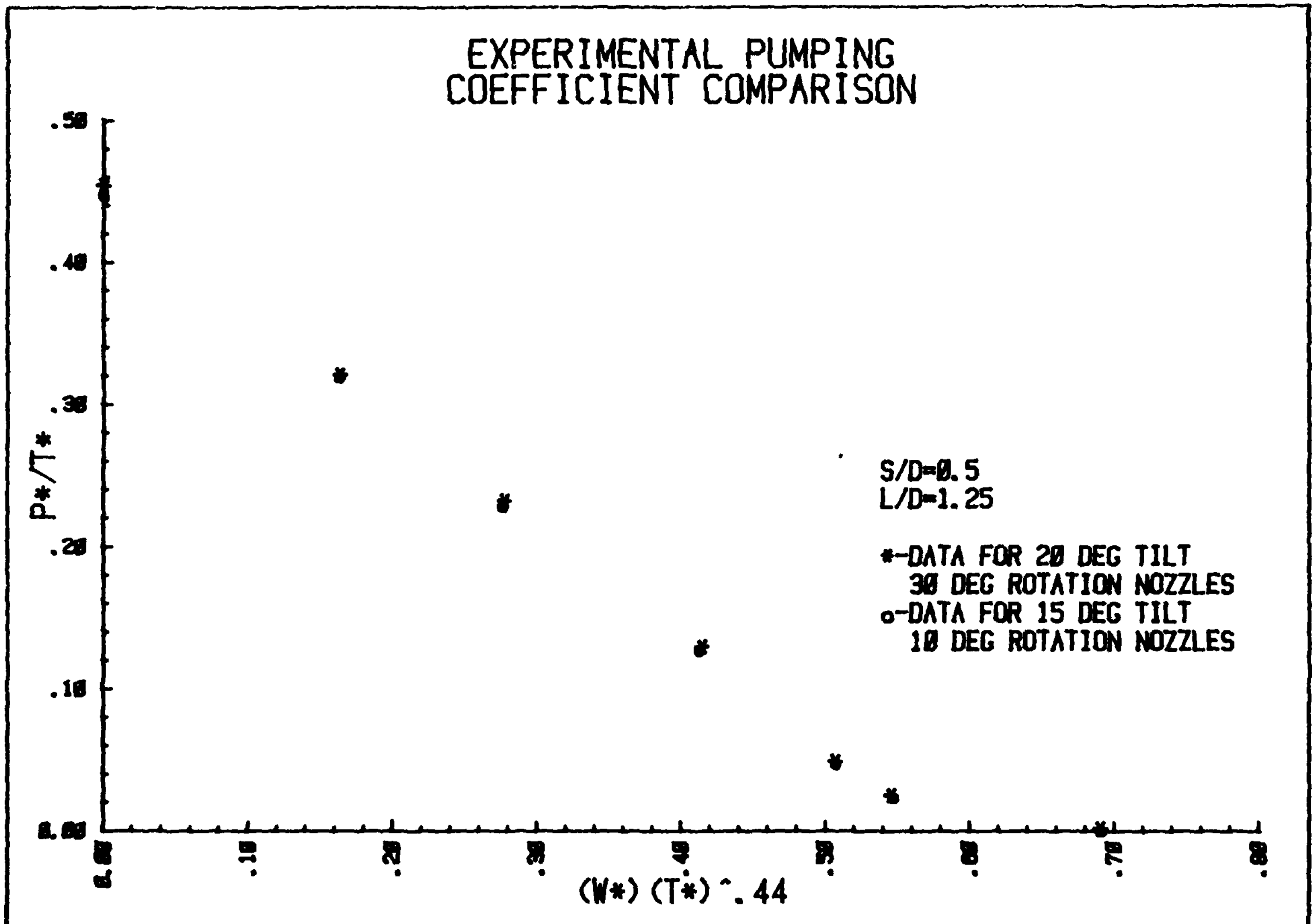

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 20 DEG TILT
30 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*) (T*) ^. 44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 72.1

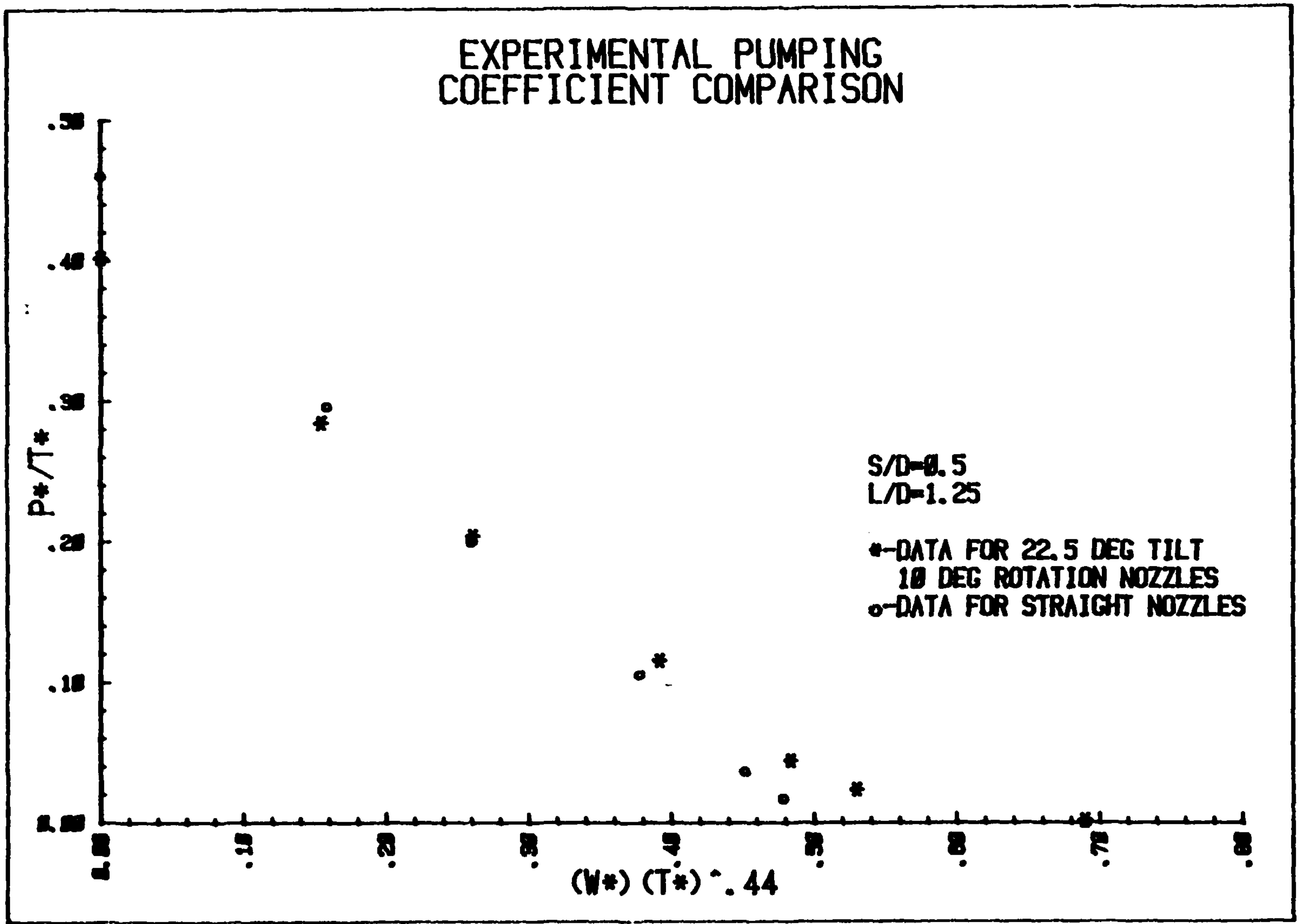
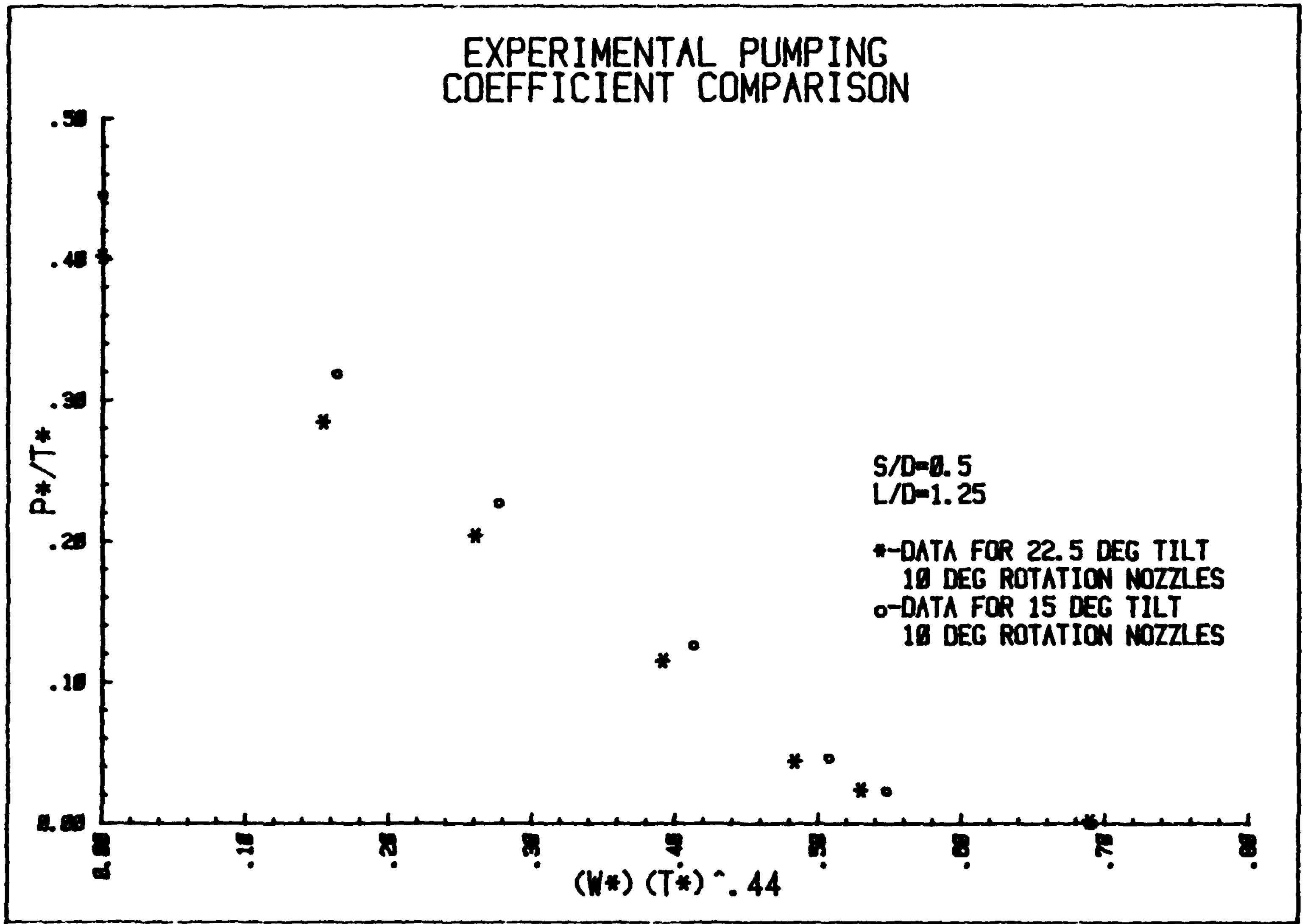

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*)^.44
S/D=0.5
L/D=1.25
*-DATA FOR 22.5 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 73


EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 22.5 DEG TILT
10 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
FIGURE 73.1

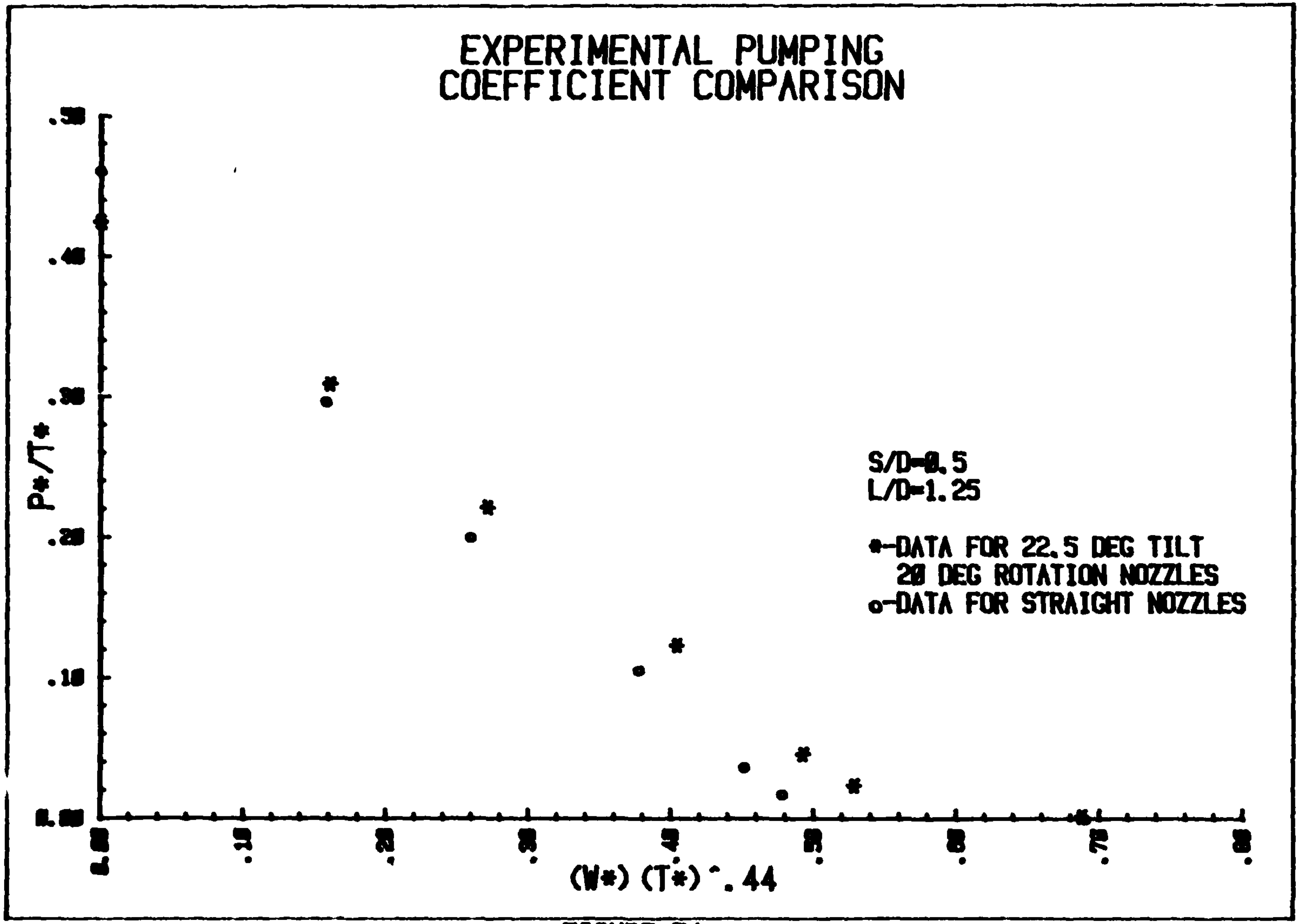

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
P*/T*
.50
.40
.30
.20
.10
0.00
.10
.20
.30
.40
.50
.60
.70
.80
(W*) (T*) ^.44
S/D=0.5
L/D=1.25
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR STRAIGHT NOZZLES

FIGURE 74

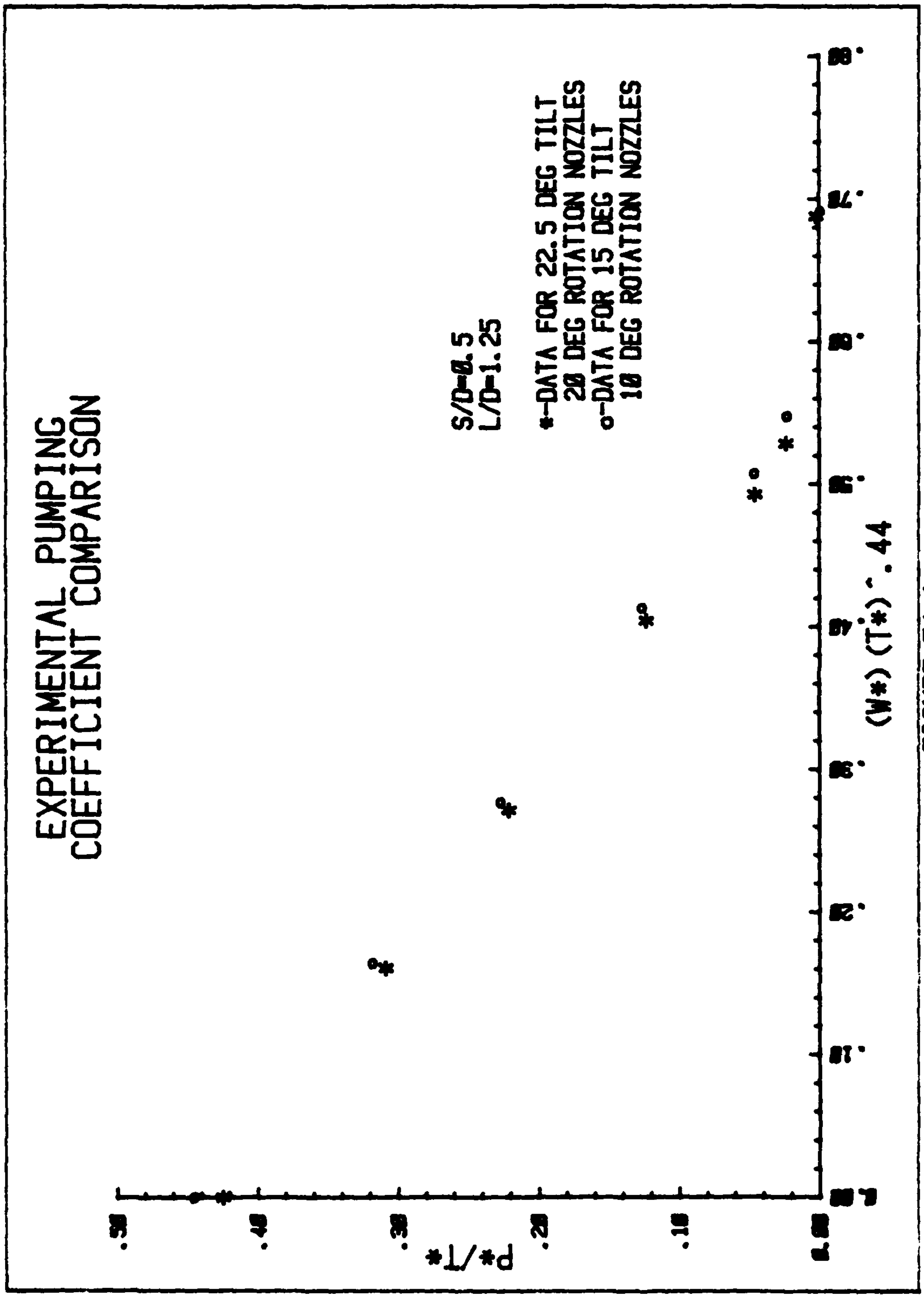

EXPERIMENTAL PUMPING
COEFFICIENT COMPARISON
S/D=0.5
L/D=1.25
*-DATA FOR 22.5 DEG TILT
20 DEG ROTATION NOZZLES
o-DATA FOR 15 DEG TILT
10 DEG ROTATION NOZZLES
P*/T*
(W*)(T*)^.44
0.00
.10
.20
.30
.40
.50
.60
.70
.80

FIGURE 74.1

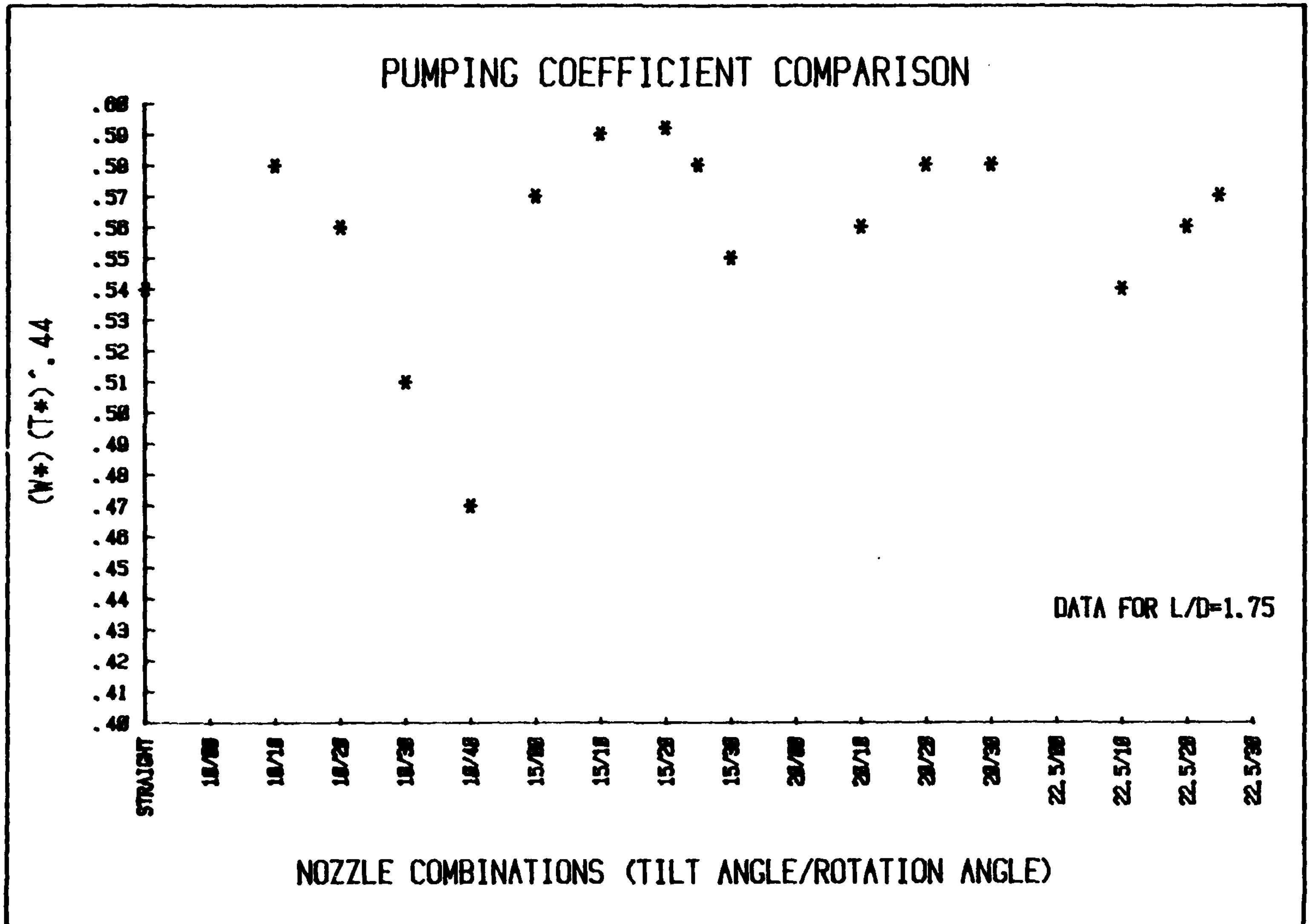

PUMPING COEFFICIENT COMPARISON
(W*)(T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
DATA FOR L/D=1.75
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 75

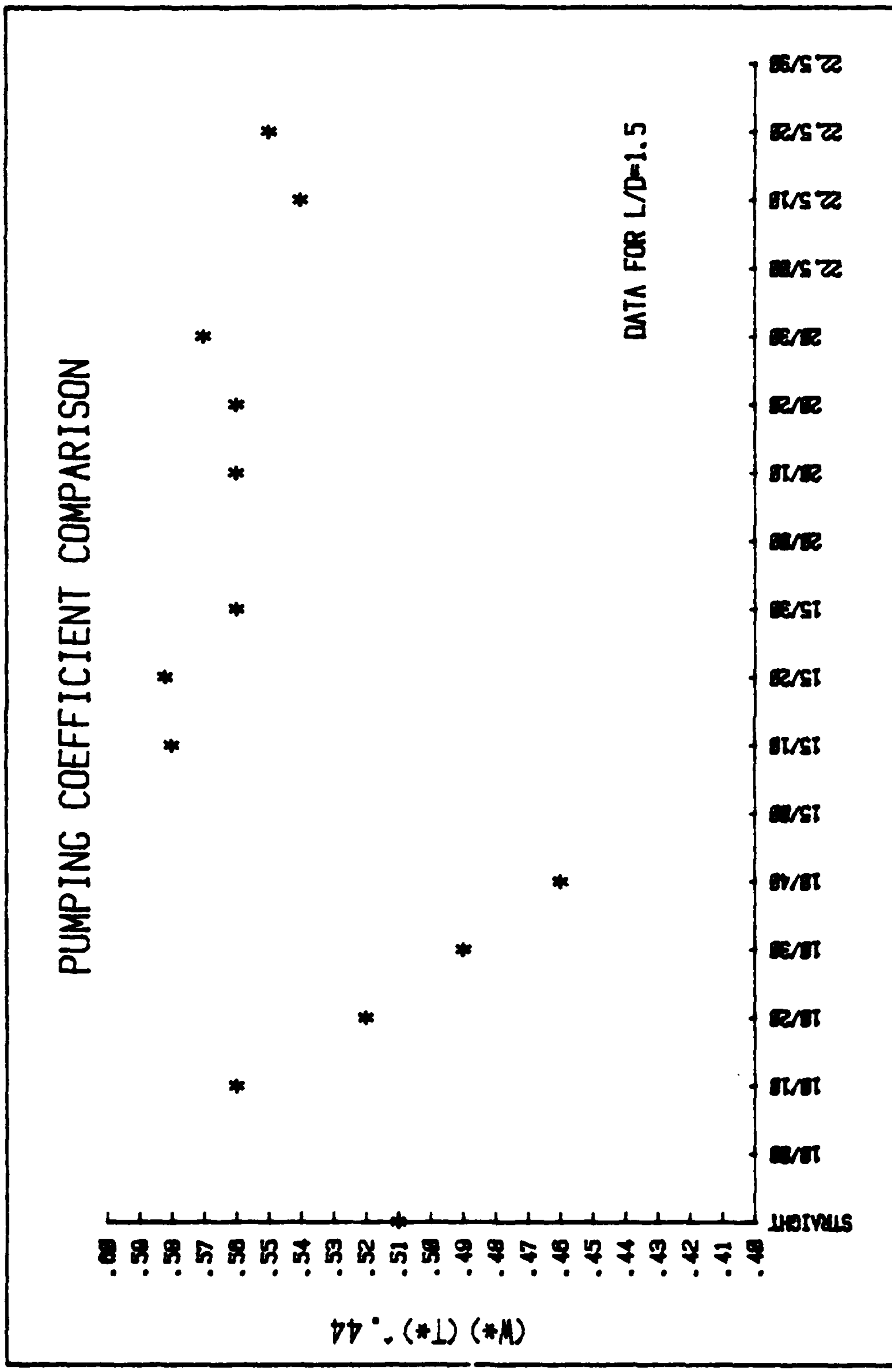

PUMPING COEFFICIENT COMPARISON
DATA FOR L/D=1.5
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)
(W*)(T*)^.44
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30

FIGURE 78

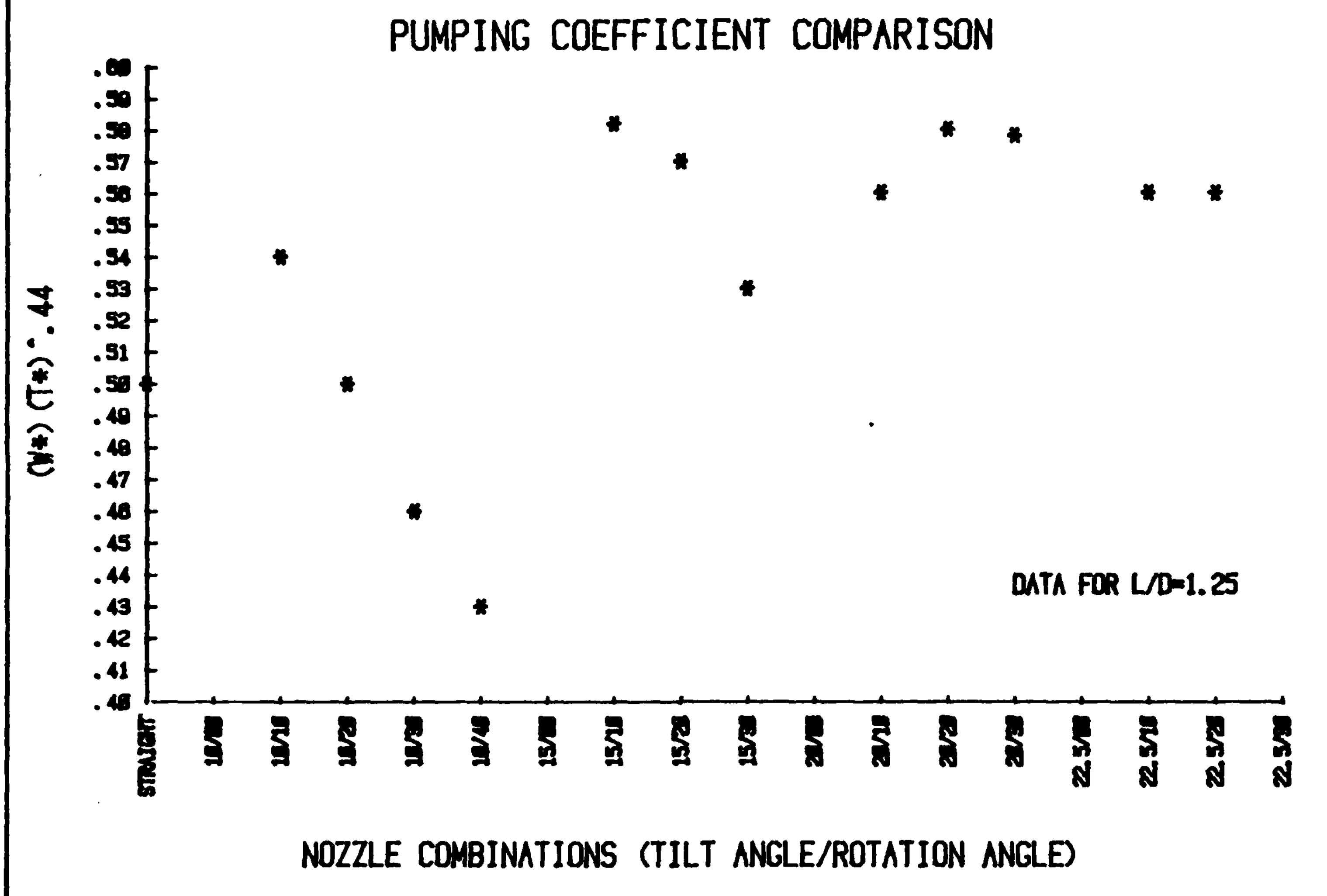

PUMPING COEFFICIENT COMPARISON
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
(W*) (T*)^.44
DATA FOR L/D=1.25
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 77

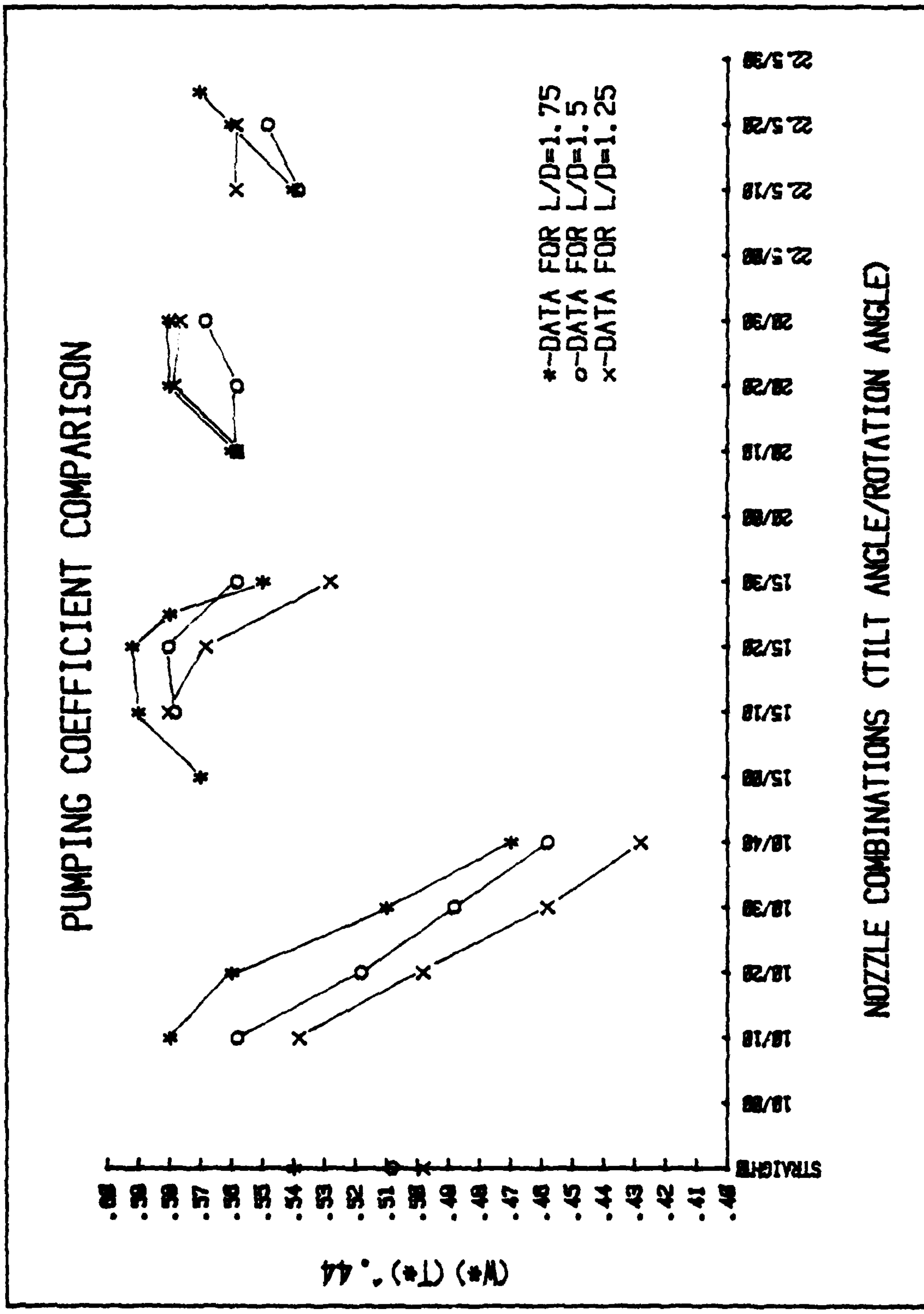
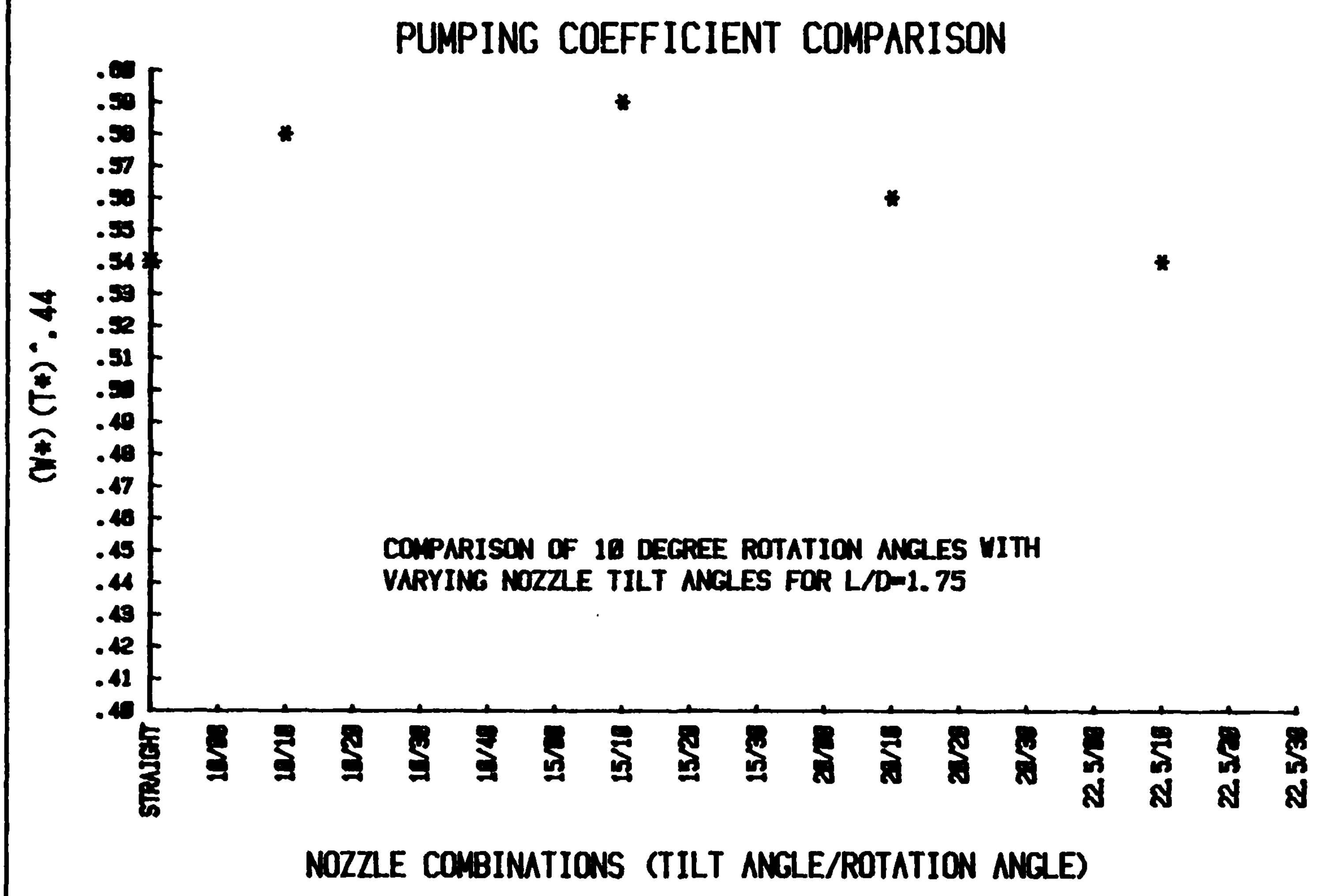

PUMPING COEFFICIENT COMPARISON
*-DATA FOR L/D=1.75
o-DATA FOR L/D=1.5
x-DATA FOR L/D=1.25
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 78



PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 10 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.75
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 79

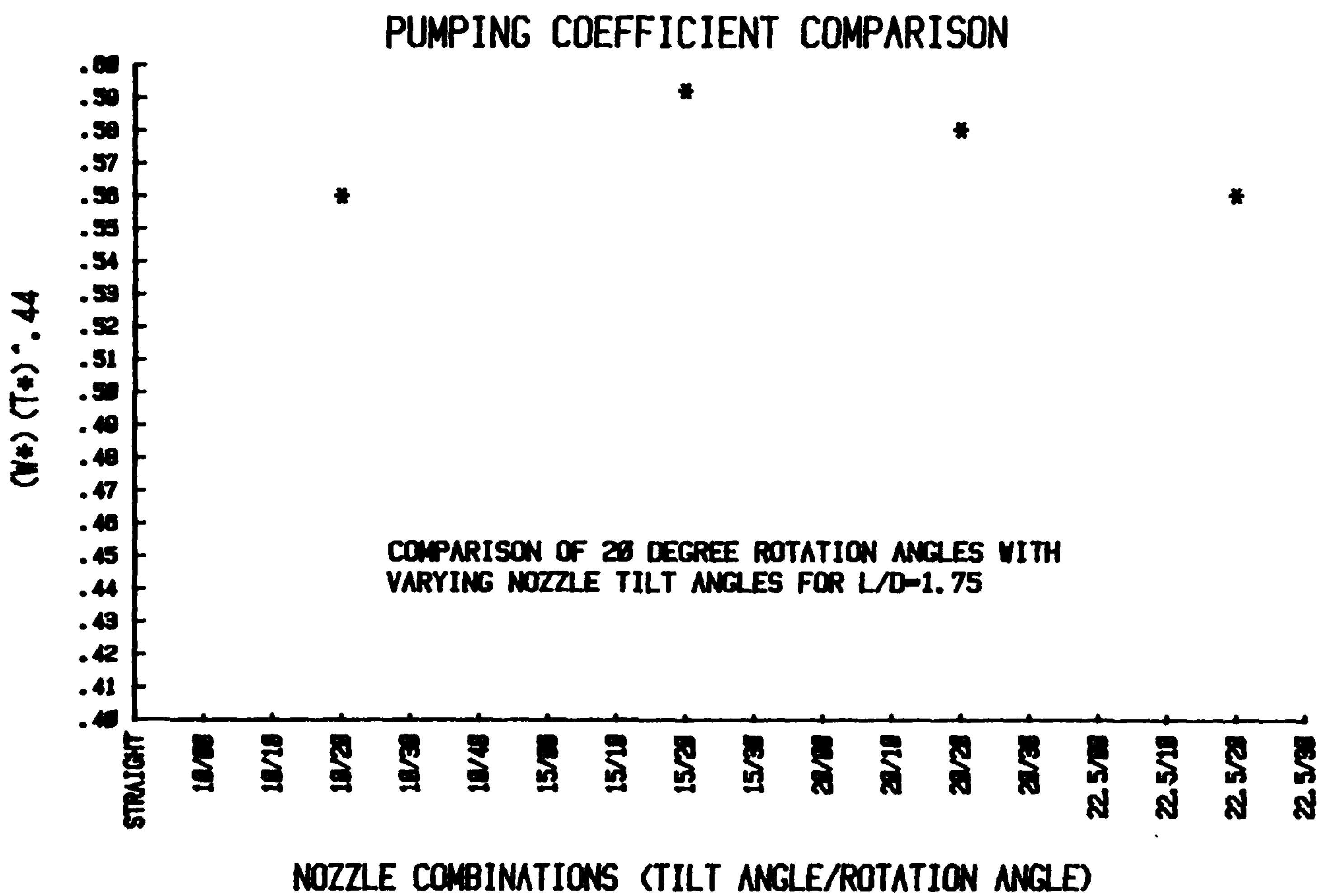

PUMPING COEFFICIENT COMPARISON
(W*)(T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 20 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.75
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 79.1

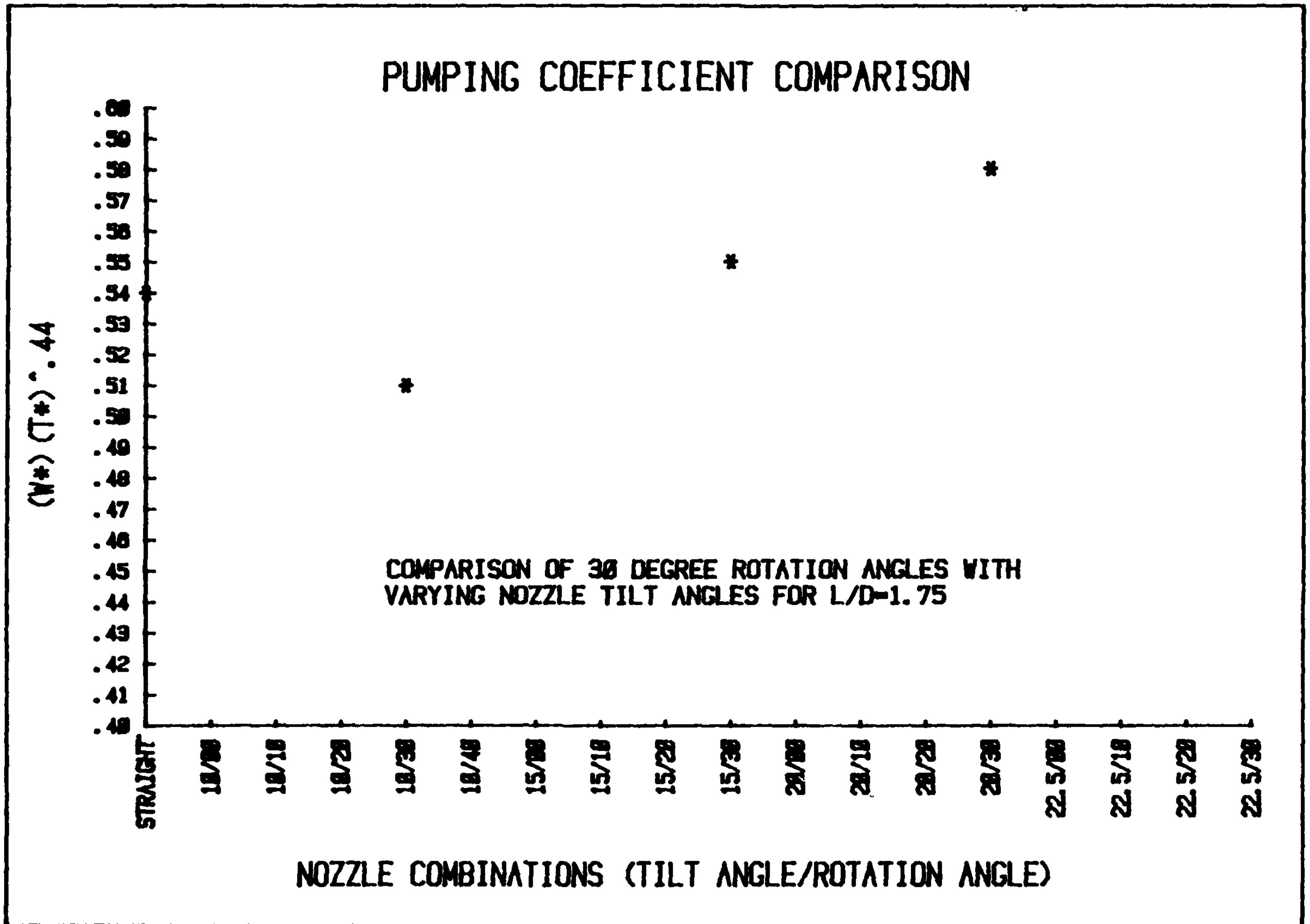
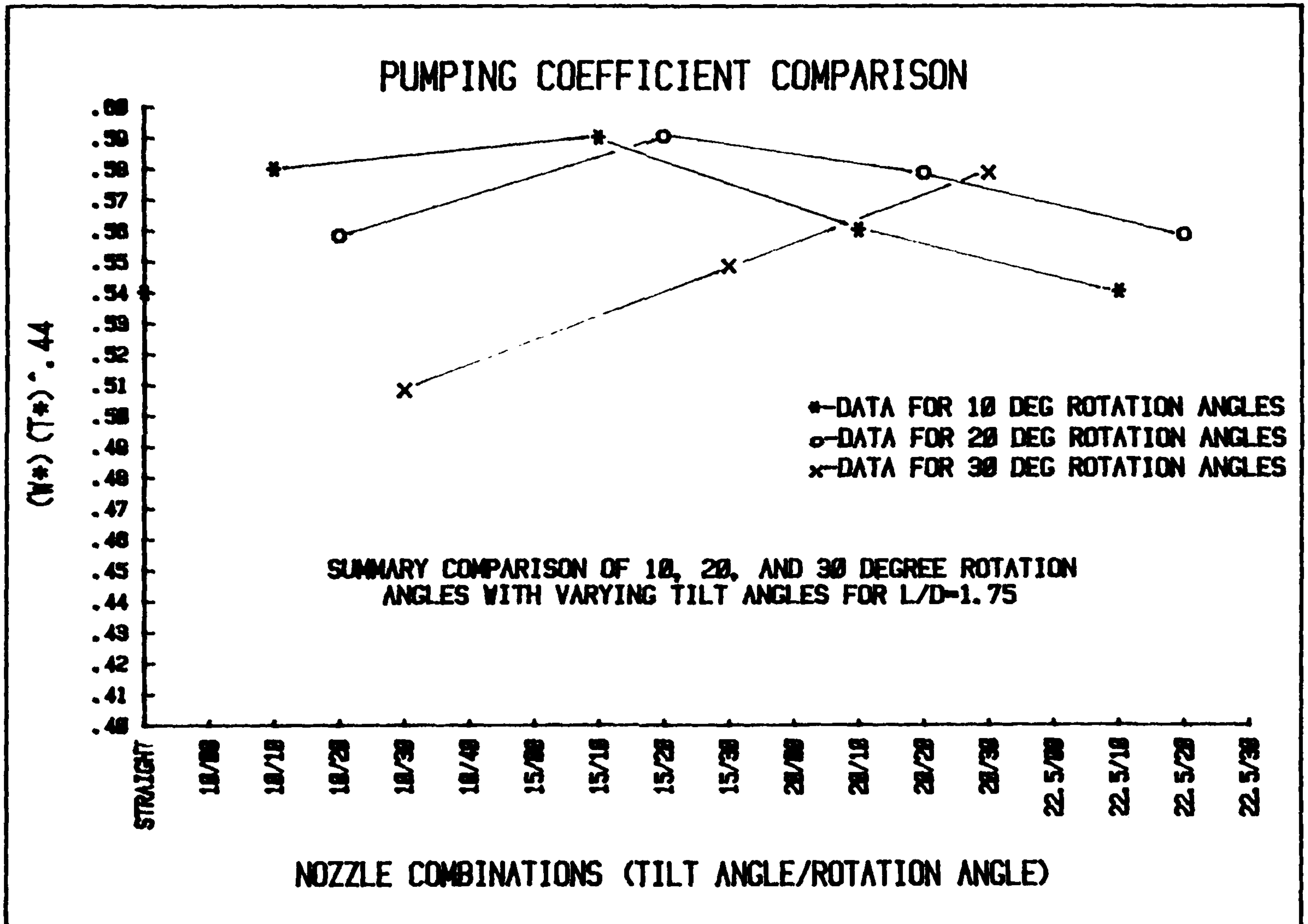

PUMPING COEFFICIENT COMPARISON
(W*)(T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 3Ø DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.75
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 79.2



PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
*-DATA FOR 10 DEG ROTATION ANGLES
o-DATA FOR 20 DEG ROTATION ANGLES
x-DATA FOR 30 DEG ROTATION ANGLES
SUMMARY COMPARISON OF 10, 20, AND 30 DEGREE ROTATION
ANGLES WITH VARYING TILT ANGLES FOR L/D=1.75
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 78.3

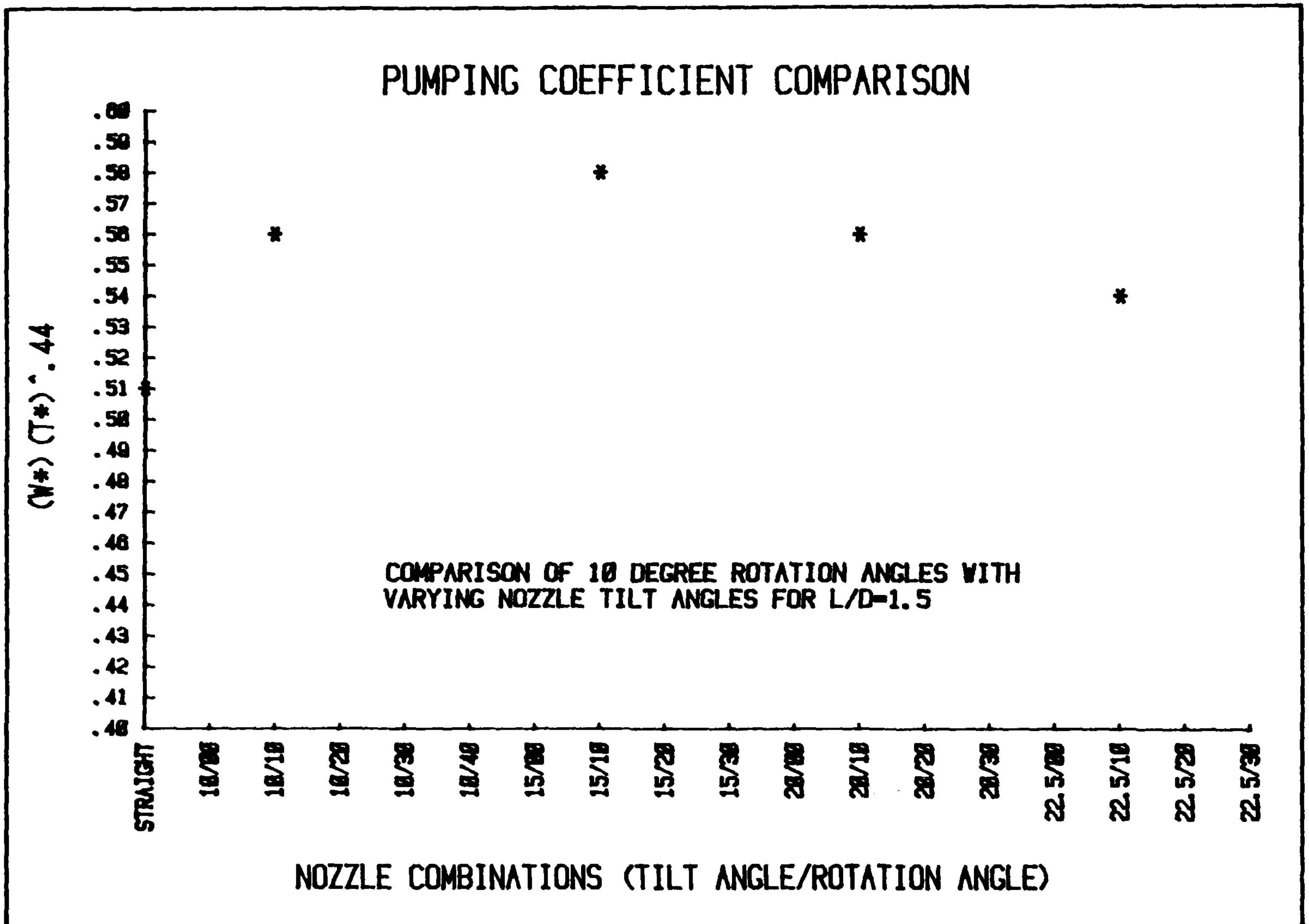

PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 10 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.5
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 80

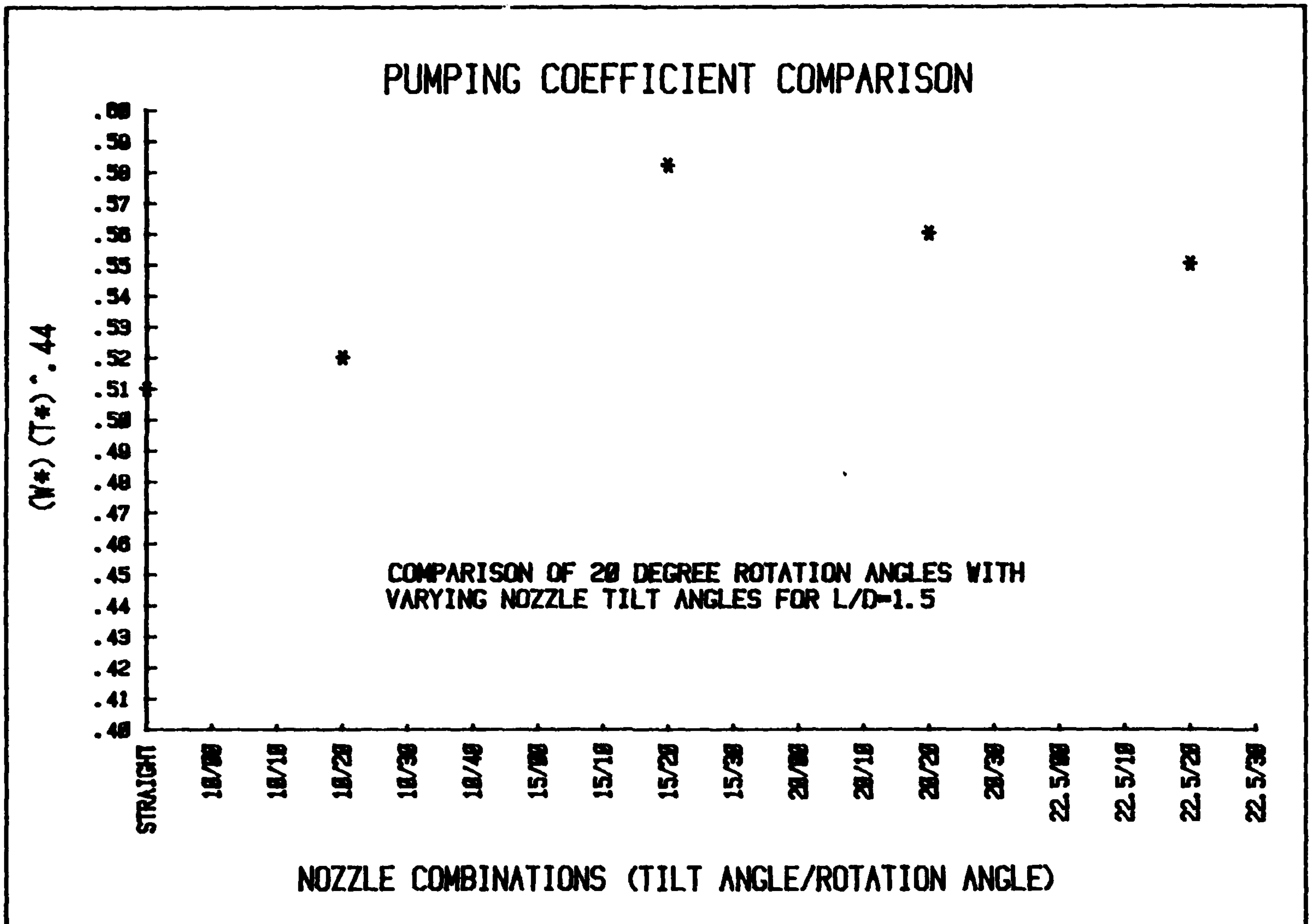
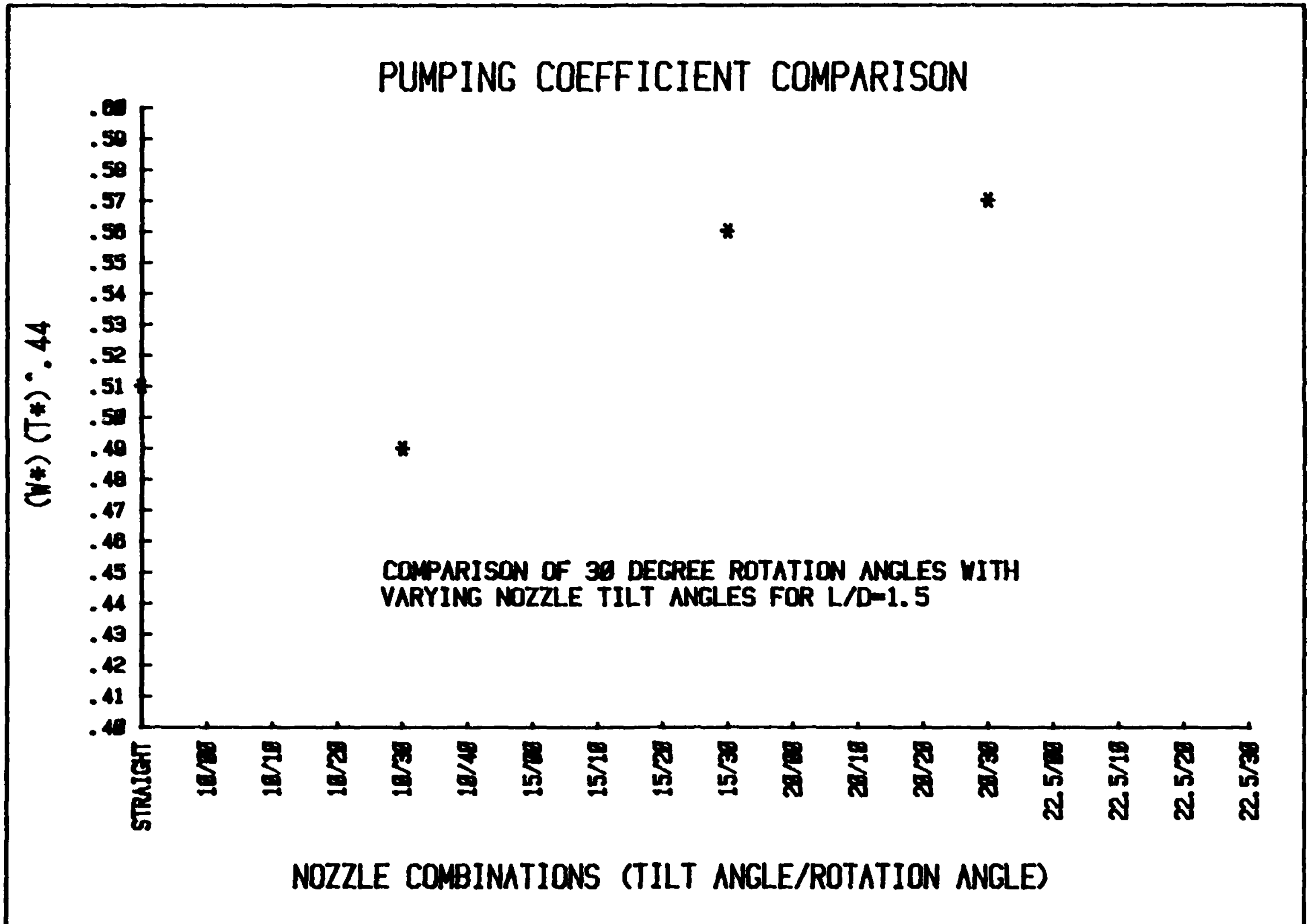
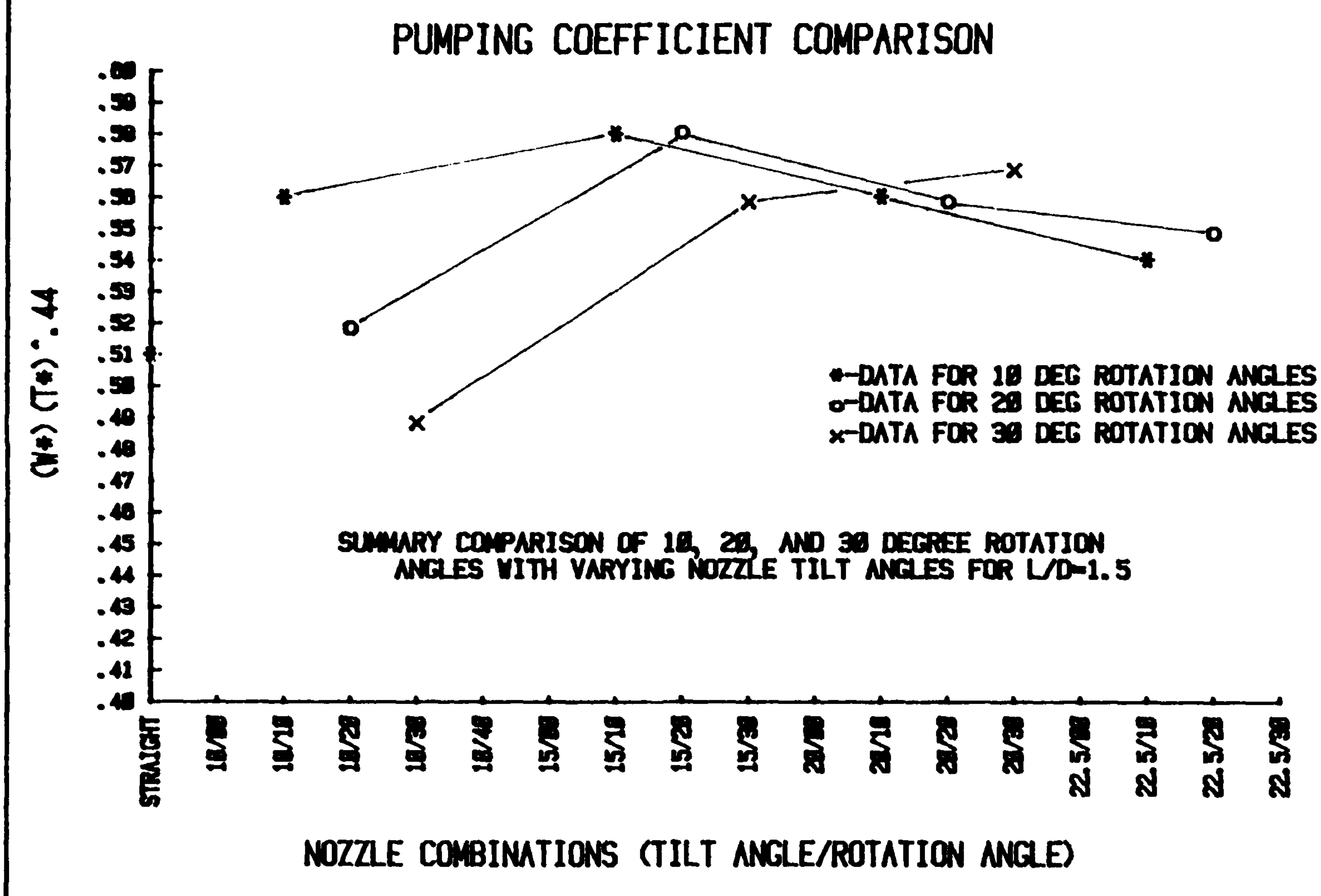

PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 20 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.5
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 80.1



PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 30 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.5
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 80.2



PUMPING COEFFICIENT COMPARISON
(W*) (T*) ^ .44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
*-DATA FOR 10 DEG ROTATION ANGLES
o-DATA FOR 20 DEG ROTATION ANGLES
x-DATA FOR 30 DEG ROTATION ANGLES
SUMMARY COMPARISON OF 10, 20, AND 30 DEGREE ROTATION
ANGLES WITH VARYING NOZZLE TILT ANGLES FOR L/D=1.5
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 80.3

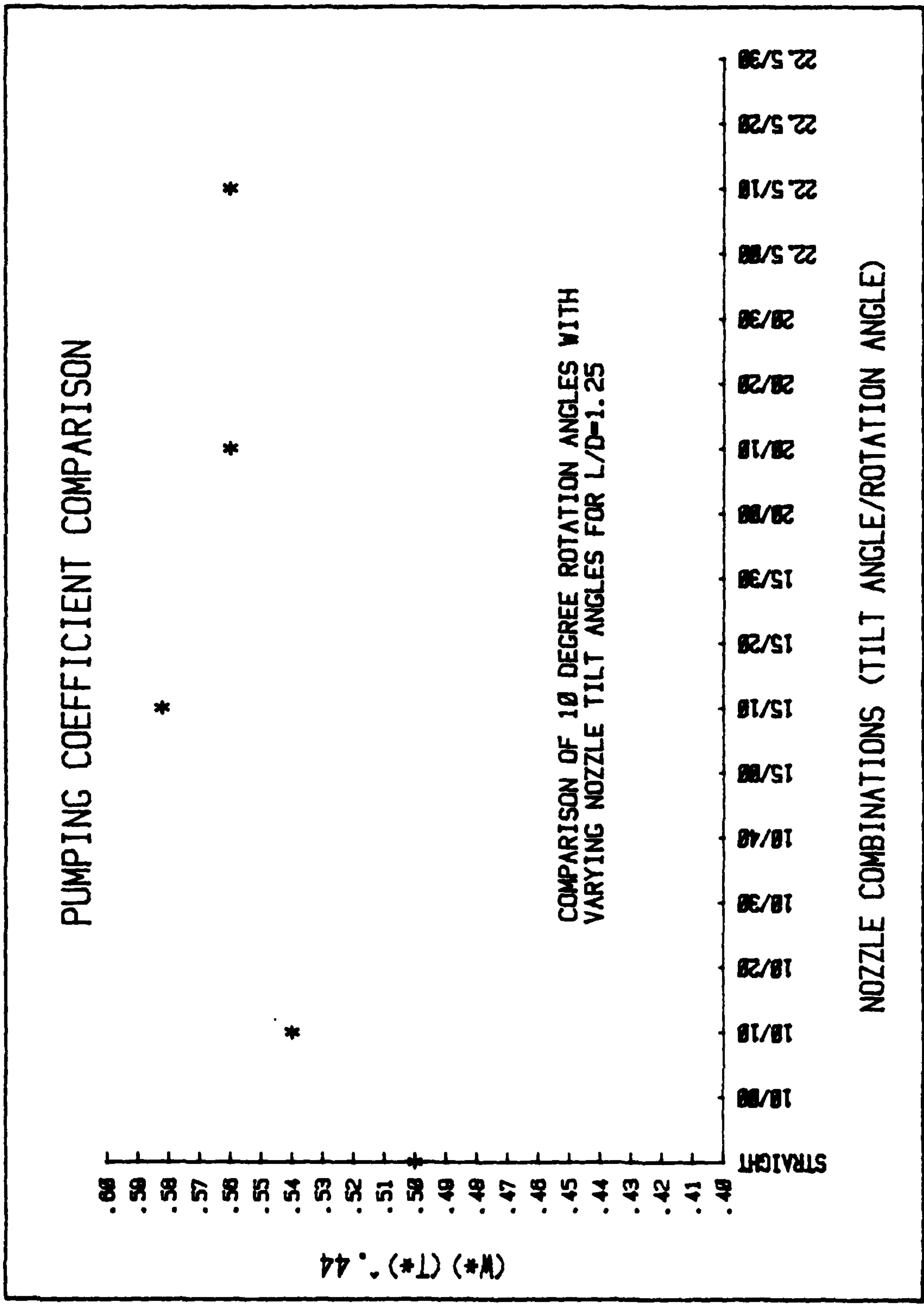

PUMPING COEFFICIENT COMPARISON
COMPARISON OF 10 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.25
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 81

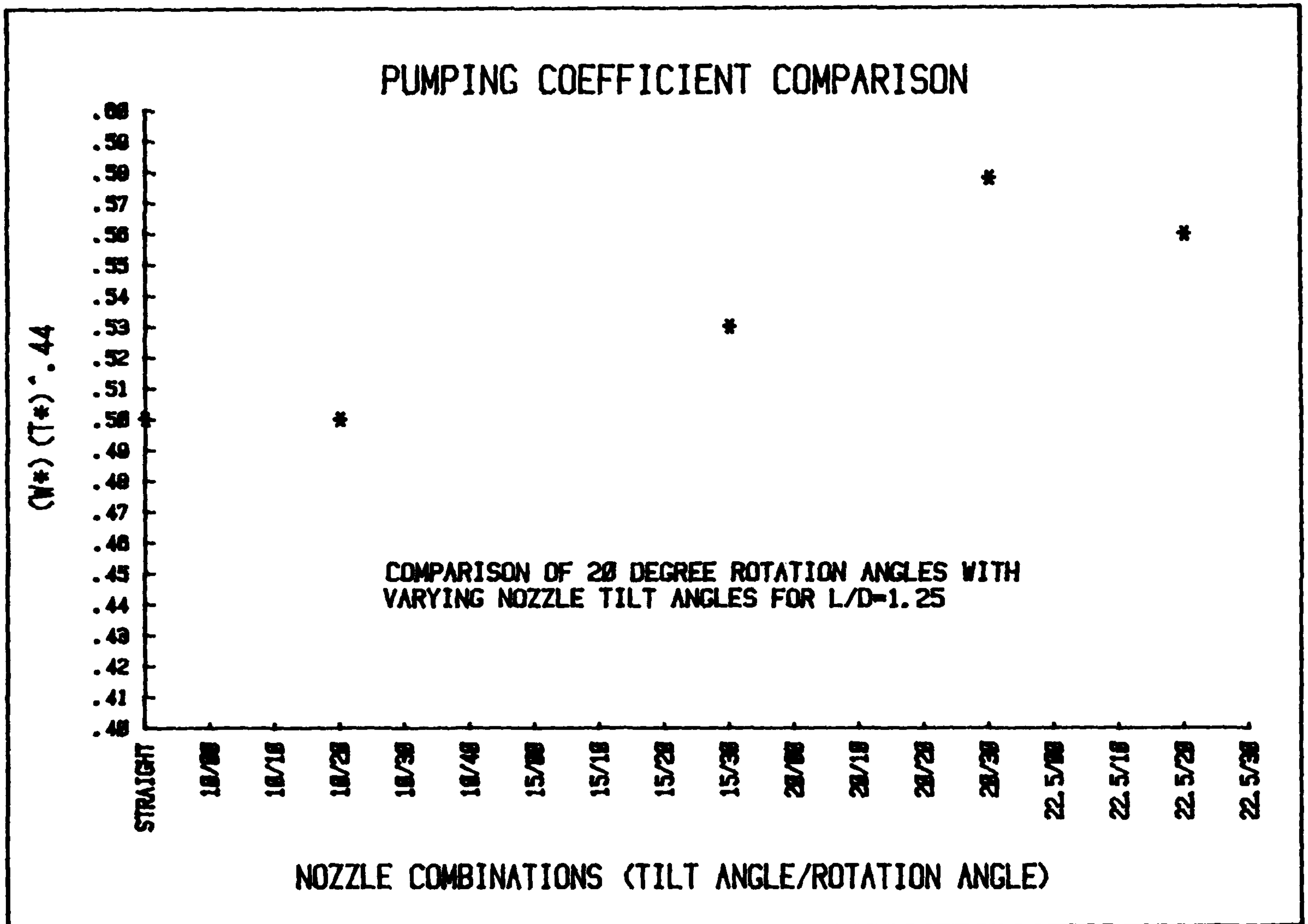

PUMPING COEFFICIENT COMPARISON
(W*) (T*) ^ .44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
COMPARISON OF 20 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.25
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE B1.1

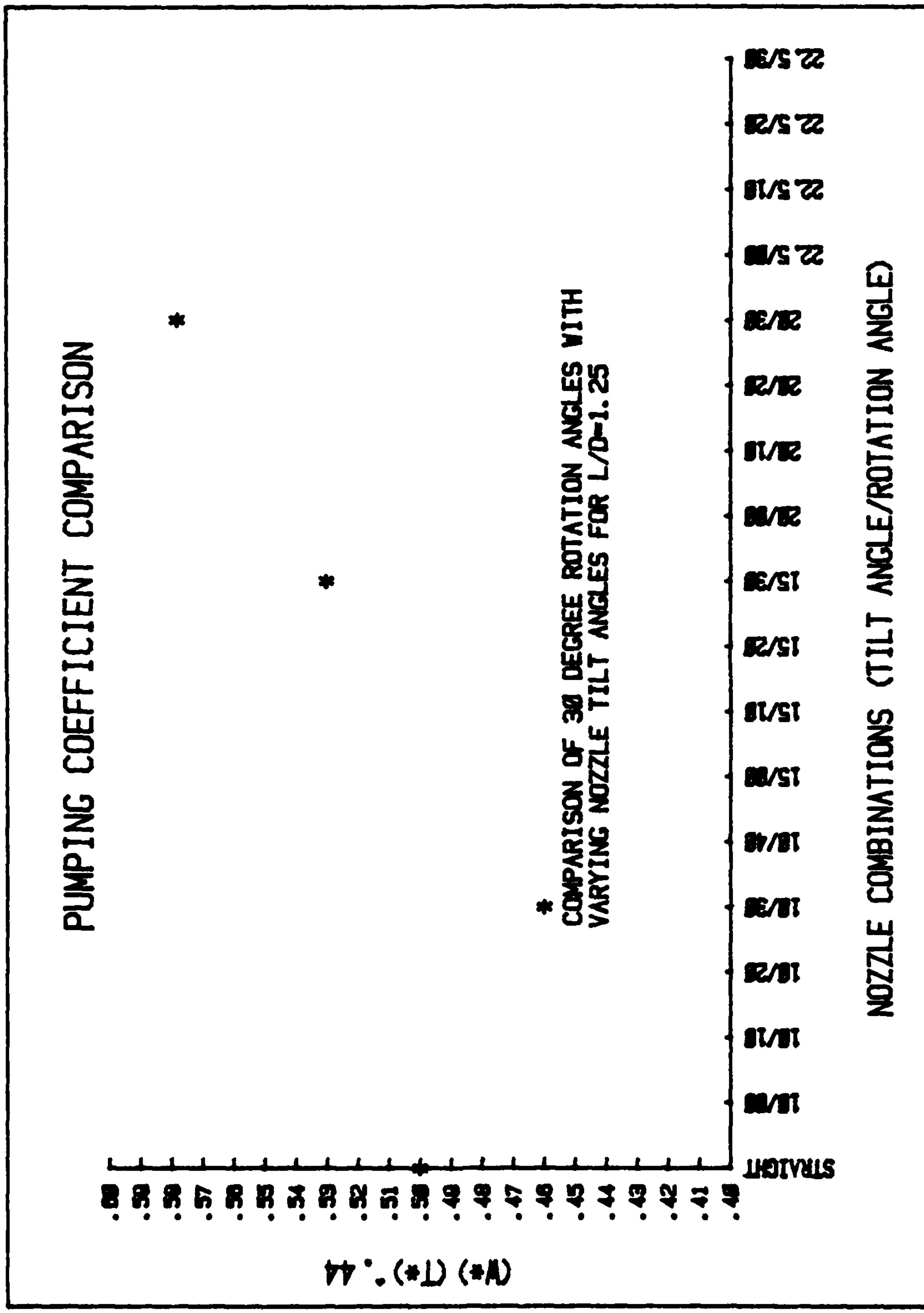

PUMPING COEFFICIENT COMPARISON
(W*) (T*)^.44
.60
.59
.58
.57
.56
.55
.54
.53
.52
.51
.50
.49
.48
.47
.46
.45
.44
.43
.42
.41
.40
STRAIGHT
10/00
10/10
10/20
10/30
10/40
15/00
15/10
15/20
15/30
20/00
20/10
20/20
20/30
22.5/00
22.5/10
22.5/20
22.5/30
* COMPARISON OF 30 DEGREE ROTATION ANGLES WITH
VARYING NOZZLE TILT ANGLES FOR L/D=1.25
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE 81.2

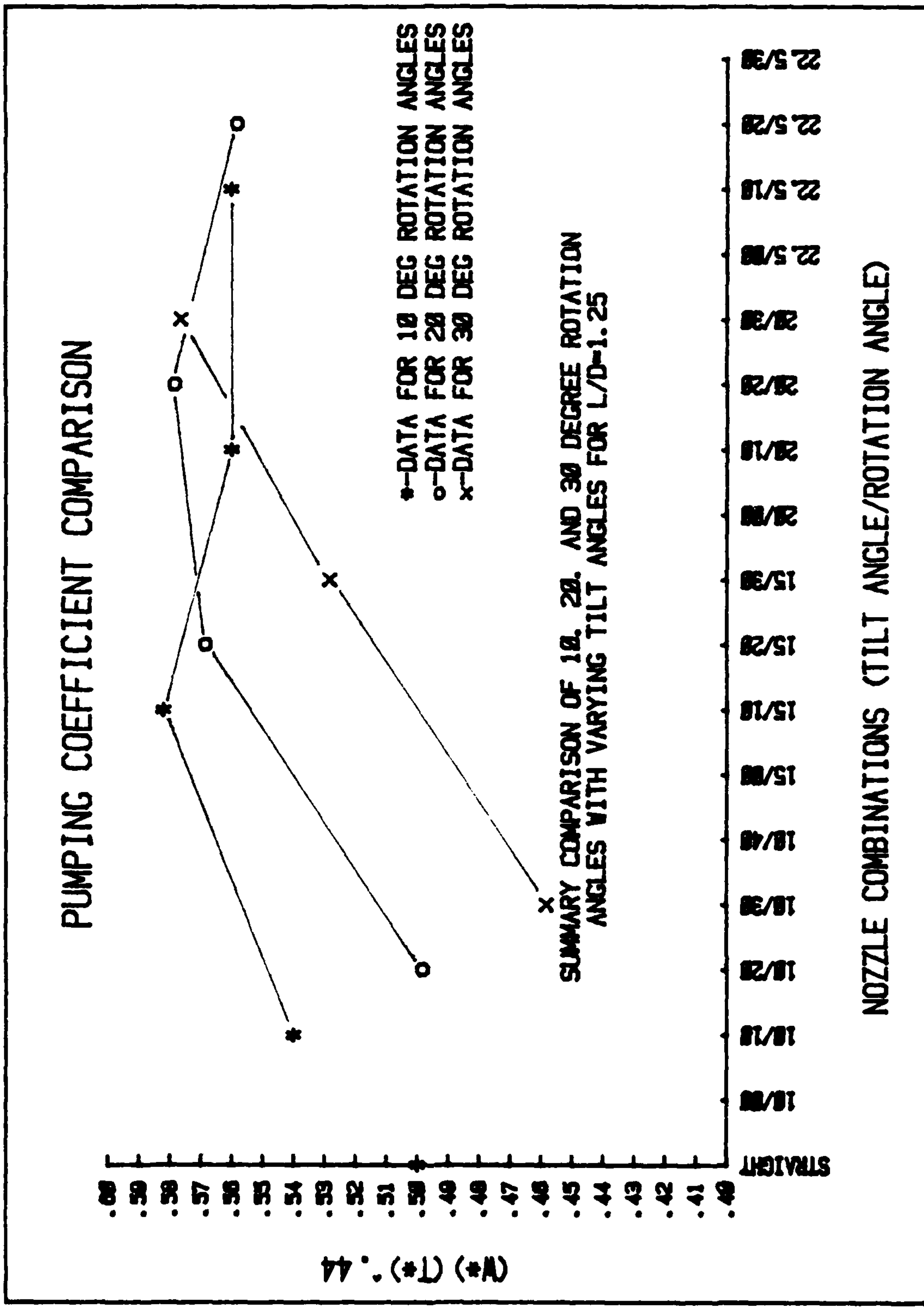

PUMPING COEFFICIENT COMPARISON
*—DATA FOR 10 DEG ROTATION ANGLES
o—DATA FOR 20 DEG ROTATION ANGLES
x—DATA FOR 30 DEG ROTATION ANGLES
SUMMARY COMPARISON OF 10, 20, AND 30 DEGREE ROTATION
ANGLES WITH VARYING TILT ANGLES FOR L/D=1.25
(W*)(T*)^.44
.60 .59 .58 .57 .56 .55 .54 .53 .52 .51 .50 .49 .48 .47 .46 .45 .44 .43 .42 .41 .40
STRAIGHT 10/00 10/10 10/20 10/30 10/40 15/00 15/10 15/20 15/30 20/00 20/10 20/20 20/30 22.5/00 22.5/10 22.5/20 22.5/30
NOZZLE COMBINATIONS (TILT ANGLE/ROTATION ANGLE)

FIGURE B1.3

SUMMARY OF TABULATED DATA

L/D RATIO	S/D RATIO	NOZZLE TILT	NOZZLE ROTATION	$(U^*)(T^*)^{.44}$	ACCURACY	DATA PCD	DATA MSD	DATA VTD	DTG/RUN	COMMENTS
1.75	0.5	00	00	.54	±.005	X	X	X	0208811	Calibration run. Data compared extremely well with LEMKE-STAEHLI data.
	0.5	10	10	.58	±.005	X			1908814	Better than straight but below the 15/20 nozzles.
		10	20	.56	±.005	X			1908813	Better than straight but below the 15/20 nozzles.
		10	30	.51	±.005	X			1908812	Worse than both the straight and the 15/20 nozzles.
		10	40	.47	±.005	X			1908811	Much worse than the straight and the 15/20 nozzles.
	0.5	15	00	.57	±.005	X	X	X	0308811	Better than the straight but below the 15/20 nozzles. One positive MSD point.
		15	00	NA	NA	X	X		0508811	MSD and rotation angle comparison run with the base plate fixed at zero.
		15	00	NA	NA	X	X		0508812	MSD and rotation angle comparison run with the base plate fixed at the peak *position 'A' value.*
		15	00	NA	NA	X	X		0508813	MSD and rotation angle comparison run with the base plate rotated for peak position 'A' pressure values.
		15	10	.59	±.005	X	X	X	1008811	Better than straight nozzles but slightly below 15/20 nozzles. VTD edge effects.
		15	20	.59+	±.005	X	X	X	1008812	Best nozzle combination based on PCD. VTD adequate. MSD had one positive point
	0.5	15	25	.58	±.0025	X	X	X	1208811	S/D comparison run. Better than straight but below 15/20 nozzles. Positive MSD pressure point.
	0.4	15	25	.585	±.0025	X	X	X	1208812	S/D comparison. Slightly better than with S/D=0.5 and positive MSD point was intermittent.
	0.25	15	25	.55	±.0025	X	X	X	1308811	S/D comparison run. Better than straight nozzles but below other S/D comparison data. Intermittent positive MSD point.
	0.5	15	30	.55	±.0025	X	X	X	1108811	Better than straight but below 15/20 nozzles. One slightly positive MSD point
	0.5	20	10	.56	±.0025	X	X	X	1708811	Better than straight but below 15/20 nozzles. Generally poor MSD and VTD profiles.
		20	20	.58	±.01	X	X	X	1808811	Better than straight but slightly below 15/20 nozzles. One positive MSD pressure point but fairly flat VTD profile.

TABLE 1.1 SUMMARY OF TABULATED DATA

SUMMARY OF TABULATED DATA (CONTINUED)

L/D RATIO	S/D RATIO	NOZZLE		$(W^*)(T^*)^{.44}$	ACCURACY	DATA			DTG/RUN	COMMENTS
		TILT	ROTATION			PCD	MSD	VTD		
1.75	0.5	20	30	.58	±.0025	X			1908818	Better than straight nozzles but just below 15/20 nozzles.
	0.5	22.5	10	.54	±.0025	X			1908817	Slightly better than straight nozzles but well below 15/20 nozzles.
		22.5	20	.56	±.005	X			1908816	Better than straight nozzles but below 15/20 nozzles.
		22.5	25	.57	±.0025	X			1908815	Better than straight nozzles but below 15/20 nozzles.
1.5	0.5	00	00	.51	±.01	X	X	X	2008811	Straight nozzle calibration run. PCD worse than L/D=1.75 straight nozzles but MSD and VTD profiles were essentially the same for both mixing stacks.
	0.5	10	10	.56	±.0025	X			2308811	Better than straight nozzles but below 15/20 nozzles.
		10	20	.52	±.005	X			2308812	Slightly better than straight nozzles but well below 15/20 nozzles.
		10	30	.49	±.0025	X			2308813	Worse than the straight or the 15/20 nozzle combinations.
		10	40	.46	±.01	X			2308814	Worst nozzle combination for the L/D=1.5 mixing stack.
	0.5	15	10	.58	±.0025	X			2308815	Better than the straight nozzles but just below the 15/20 nozzles.
		15	20	.58	±.0025	X			2308816	PCD data run only. Best nozzle combinatio as verified by the full data run.
		15	20	.58+	±.0025	X	X	X	2408811	Essentially the same pumping coefficient as the L/D=1.75 stack. Good MSD and rotation profile, but more pronounced peaks and troughs in the VTD profile compared to the L/D=1.75 stack and 15/20 nozzles.
		15	30	.56	±.0025	X			2308817	Better than straight but below 15/20 nozzles.
	0.5	20	10	.56	±.005	X			2408812	Better than straight but below the 15/20 nozzles.
		20	20	.56	±.0025	X			2408813	Better than straight but below the 15/20 nozzles.
		20	30	.57	±.005	X			2408814	Better than straight but below the 15/20 nozzles.
	0.5	22.5	10	.54	±.0025	X			2408815	Better than straight but below the 15/20 nozzles.
		22.5	20	.55	±.01	X			2408816	Better than straight but below the 15/20 nozzles.

TABLE 1.2 SUMMARY OF TABULATED DATA (CONT)

SUMMARY OF TABULATED DATA (CONTINUED)

L/D RATIO	S/D RATIO	NOZZLE TILT	NOZZLE ROTATION	$(W^*)(T^*)^{.44}$	ACCURACY	DATA PCD	DATA MSD	DATA VTD	DTG/RUN	COMMENTS
1.25	0.5	00	00	.50	±.005	X	X	X	2508811	PCD below L/D=1.5 and L/D=1.75 straight nozzles. MSD profile is good, but still remains below the longer mixing stacks. VTD profile has more pronounced peaks and troughs than the longer stacks.
	0.5	10	10	.54	±.0025	X			2608811	Better than the straight but below the 15/10 nozzles.
		10	20	.50	±.0025	X			2608812	Just slightly better than the straight nozzles and well below the 15/10 nozzles.
		10	30	.46	±.005	X			2608813	Well below the straight or the 15/10 nozzles.
		10	40	.43	±.01	X			2608814	Worst nozzle combination for any of the mixing stacks tested.
	0.5	15	10	.58+	±.0025	X			2508815	PCD data only, but should be the best combination for this mixing stack.
		15	20	.57	±.005	X			2608816	This combination should have been the best combination for the L/D=1.25 stack based on past data, but it fell off for unexplained reasons.
		15	20	.56	±.0025	X	X	X	2708812	More accurate data. Confirms drop in pumping coefficient. MSD and VTD profiles are above average, and no positive pressure points. VTD profile does show more pronounced peaks and troughs.
		15	30	.53	±.01	X			2608817	Slightly better than straight nozzles but worse than 15/10 nozzles.
	0.5	20	10	.56	±.005	X			2608818	Better than the straight nozzles but below the 15/10 nozzles.
		20	20	.58	±.0025	X			2608819	PCD shows a strong contender for best nozzle combination selection.
		20	20	.58	±.0025	X	X	X	2708813	Good PCD, but MSD profile is markedly poor and has two positive pressure points. Some misalignment on VTD profile, but in general, horizontal profile is better and diagonal profile is worse than 15/20 comb
		20	30	.58	±.0025	X			2708811	PCD just below 20/20 and 15/10 nozzles. All are very close.
	0.5	22.5	10	.56	±.005	X			2708814	Better than the straight nozzles but below the 15/10 nozzles.
		22.5	20	.56	±.005	X			2708815	Better than the straight nozzles but below the 15/10 nozzles.

TABLE 1.3 SUMMARY OF TABULATED DATA (CONT)

DATA TAKEN ON: 2 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
STRAIGHT NOZZLES-CAL RUN

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 0 [DEG]
ROTATION ANGLE: 0 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 30.09 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	21.9	56.4	108.8	67.3	3.20	3.21	0.00	0.000	*******
2	0.69	21.8	56.4	109.2	67.3	4.10	2.12	0.00	12.566	*******
3	0.69	21.7	56.6	109.4	67.3	4.65	1.44	0.00	25.133	*******
4	0.70	22.1	56.6	109.6	67.3	5.45	0.81	0.00	50.265	*******
5	0.70	22.0	56.4	109.6	67.3	5.95	0.30	0.00	100.531	*******
6	0.69	22.0	56.6	109.8	67.3	6.05	0.14	0.00	150.796	*******
7	0.70	22.0	56.4	109.8	67.3	6.10	0.10	0.00	201.062	*******
8	0.70	22.0	56.6	109.8	67.3	6.15	0.06	0.00	245.044	*******
9	0.70	22.0	56.2	109.8	67.3	6.20	0.01	0.00	*******	*******

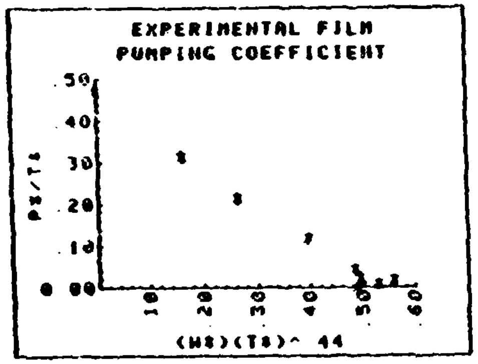
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4365	0.9270	0.4708	0.0000	3.7501	0.0000	180.31	72.13	72.13	0.062
2	0.1675	0.2907	0.9263	0.3138	0.1620	3.7416	0.6268	179.55	82.91	71.83	0.061
3	0.2769	0.1990	0.9260	0.2149	0.2676	3.7323	1.0333	178.87	89.83	71.55	0.061
4	0.4115	0.1102	0.9257	0.1190	0.3977	3.7665	1.5499	180.29	99.54	72.12	0.062
5	0.5019	0.0411	0.9257	0.0444	0.4851	3.7587	1.8865	179.69	105.25	71.88	0.061
6	0.5144	0.0192	0.9254	0.0207	0.4971	3.7580	1.9330	179.65	106.06	71.87	0.061
7	0.5795	0.0137	0.9254	0.0148	0.5601	3.7587	2.1783	179.67	110.41	71.87	0.061
8	0.5472	0.0082	0.9254	0.0089	0.5289	3.7579	2.0564	179.61	108.23	71.85	0.061
9	******	0.0007	0.9254	0.0007	******	3.7594	1.9817	179.66	******	71.87	0.061

TABLE 2 - PCD DATA FOR STRAIGHT NOZZLES WITH L/D=1.75 STACK.

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	VE FT/SEC
1	******	0.0000	0.9270	0.0000	*******	3.750	*******	******
2	******	0.0000	0.9263	0.0000	*******	4.368	*******	******
3	******	0.0000	0.9260	0.0000	*******	4.766	*******	******
4	******	0.0000	0.9257	0.0000	*******	5.316	*******	******
5	******	0.0000	0.9257	0.0000	*******	5.645	*******	******
6	******	0.0000	0.9254	0.0000	*******	5.691	*******	******
7	******	0.0000	0.9254	0.0000	*******	5.937	*******	******
8	******	0.0000	0.9254	0.0000	*******	5.814	*******	******
9	******	0.0000	0.9254	0.0000	*******	******	*******	******



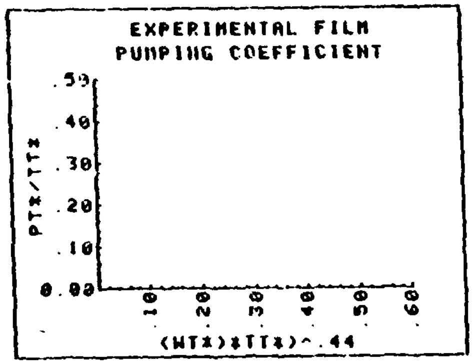
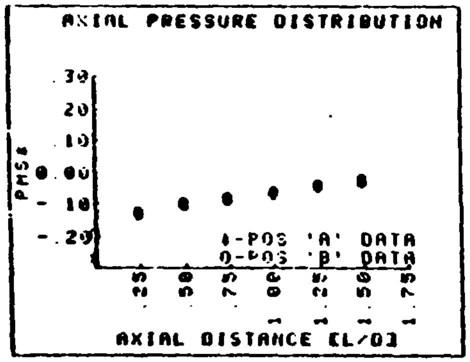


TABLE 2.1 - PCD DATA (CONT) FOR STRAIGHT NOZZLES WITH L/D=1.75 STACK

MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:				DIAGONAL (POSITION 'B') DATA:			
X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*	X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.990	0	-0.273	0.00	-1.450	0	-0.199
0.25	-0.920	0	-0.126	0.25	-0.930	0	-0.127
0.50	-0.720	0	-0.099	0.50	-0.710	0	-0.097
0.75	-0.610	0	-0.084	0.75	-0.600	0	-0.082
1.00	-0.490	0	-0.066	1.00	-0.480	0	-0.066
1.25	-0.310	0	-0.042	1.25	-0.310	0	-0.042
1.50	-0.200	0	-0.027	1.50	-0.190	0	-0.026



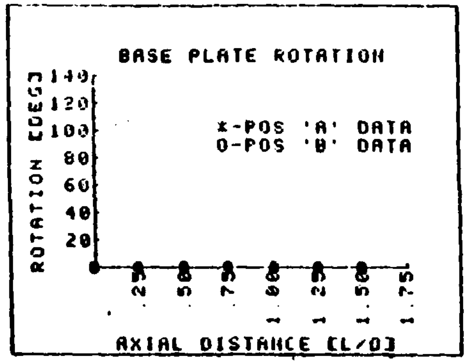
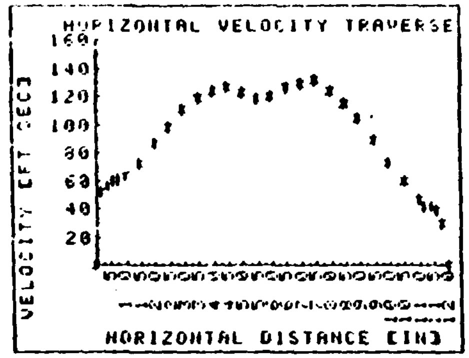


TABLE 2.2 - MSD DATA FOR STRAIGHT NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.60	0.70	0.80	0.85	0.90	1.20
V[FT/SEC]	0.00	51.50	55.63	59.47	61.30	63.08	72.84
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	1.70	2.20	2.80	3.20	3.50	3.60	3.40
V[FT/SEC]	86.59	98.62	111.26	118.94	124.39	126.15	122.60
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	3.20	3.30	3.60	3.80	3.90	3.50	3.00
V[FT/SEC]	118.94	120.78	126.15	129.61	131.31	124.39	115.16
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	2.50	1.80	1.20	0.80	0.50	0.40	0.40
V[FT/SEC]	105.13	89.20	72.84	59.47	47.01	42.05	42.05
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	0.35	0.20	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.50	1.10	2.10	2.50	2.80	3.80
V[FT/SEC]	0.00	47.01	69.73	96.35	105.13	111.26	129.61
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	5.10	6.00	6.10	5.50	4.80	4.00	3.60
V[FT/SEC]	150.15	162.86	164.22	155.93	145.67	132.98	126.15
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	3.20	3.10	3.30	3.90	4.50	5.20	5.90
V[FT/SEC]	118.94	117.07	120.78	131.31	141.04	151.62	161.50
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	6.10	5.90	5.00	3.60	2.60	2.20	1.90
V[FT/SEC]	164.22	161.50	148.67	126.15	107.21	98.62	91.65
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	1.50	1.20	0.00				

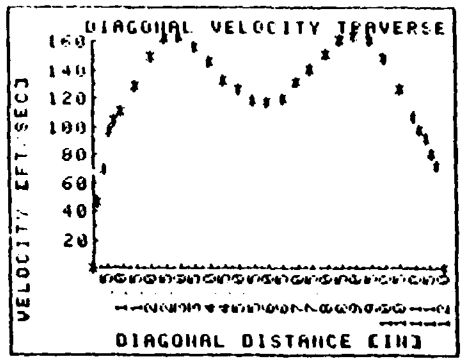


TABLE 2.3 - VTD DATA FOR STRAIGHT NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.12 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H20		DEGREES F			IN OF H20			SQUARE INCHES	SQUARE INCHES
1	0.70	22.0	58.8	112.6	71.2	3.25	3.18	0.00	0.000	*******
2	0.69	21.9	58.8	112.4	71.2	4.15	2.23	0.00	12.566	*******
3	0.69	22.1	58.6	112.2	71.2	4.75	1.61	0.00	25.133	*******
4	0.69	22.0	58.0	112.2	71.4	5.40	0.88	0.00	50.265	*******
5	0.69	21.9	59.2	112.4	71.4	5.90	0.34	0.00	100.531	*******
6	0.69	21.9	59.4	112.0	71.6	6.05	0.19	0.00	150.796	*******
7	0.69	21.8	58.2	112.6	71.8	6.15	0.01	0.00	*******	*******

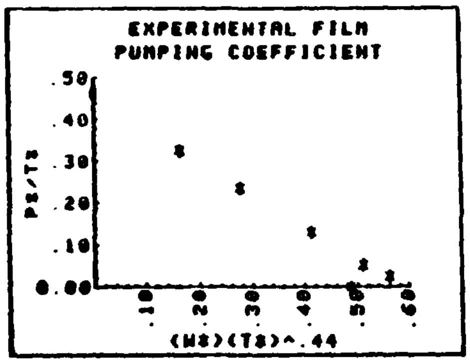
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4239	0.9277	0.4634	0.0000	3.7518	0.0000	181.41	72.57	72.57	0.062
2	0.1711	0.3040	0.9280	0.3276	0.1655	3.7462	0.6408	180.65	83.67	72.27	0.062
3	0.2896	0.2186	0.9283	0.2355	0.2802	3.7611	1.0891	181.03	91.81	72.42	0.062
4	0.4288	0.1203	0.9287	0.1296	0.4151	3.7548	1.6100	180.40	100.84	72.17	0.062
5	0.5309	0.0462	0.9283	0.0498	0.5139	3.7419	1.9868	179.61	107.23	71.85	0.061
6	0.5830	0.0248	0.9288	0.0268	0.5649	3.7412	2.1841	179.63	110.77	71.86	0.061
7	******	0.0007	0.9287	0.0007	******	3.7370	1.8946	179.29	******	71.72	0.061

TABLE 3 - PCD DATA FOR 10/10 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^ 44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9277	0.0000	*******	3.752	*******	******
2	******	0.0000	0.9260	0.0000	*******	4.387	*******	******
3	******	0.0000	0.9283	0.0000	*******	4.850	*******	******
4	******	0.0000	0.9287	0.0000	*******	5.365	*******	******
5	******	0.0000	0.9283	0.0000	*******	5.729	*******	******
6	******	0.0000	0.9280	0.0000	*******	5.925	*******	******
7	******	0.0000	0.9287	0.0000	*******	******	*******	******



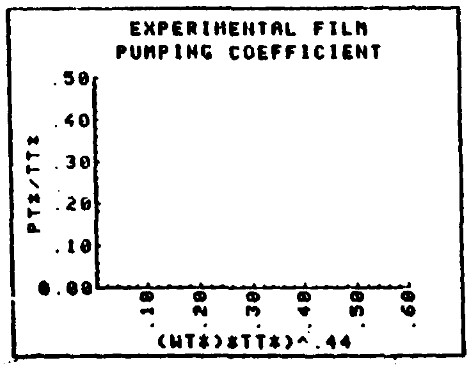


TABLE 3.1 - PCD DATA (CONT) FOR 10/10 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:		PRIMARY NOZZLE INFORMATION:		MISCELLANEOUS INFORMATION:	
LENGTH:	20.48 [IN]	TILT ANGLE:	10 [DEG]	ORIFICE DIAMETER:	6.902 [IN]
DIAMETER:	11.70 [IN]	ROTATION ANGLE:	20 [DEG]	ORIFICE BETA:	0.497
L/D RATIO:	1.75	AREA PER NOZZLE:	10.752 [IN2]	UPTAKE AREA:	107.510 [IN2]
S/D RATIO:	0.50	NUMBER OF NOZZLES:	4	ATM. PRESSURE:	30.12 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES	F		IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	59.2	112.6	71.4	3.25	3.15	0.00	0.000	*******
2	0.69	21.9	59.0	112.8	71.4	4.15	2.18	0.00	12.566	*******
3	0.70	22.1	58.6	112.6	71.8	4.80	1.56	0.00	25.133	*******
4	0.70	22.0	59.2	112.6	71.8	5.45	0.85	0.00	50.265	*******
5	0.70	22.1	59.0	112.8	71.8	6.00	0.31	0.00	100.531	*******
6	0.70	22.0	59.2	112.8	71.8	6.10	0.16	0.00	150.796	*******
7	0.70	22.0	58.6	112.6	72.0	6.25	0.01	0.00	*******	*******

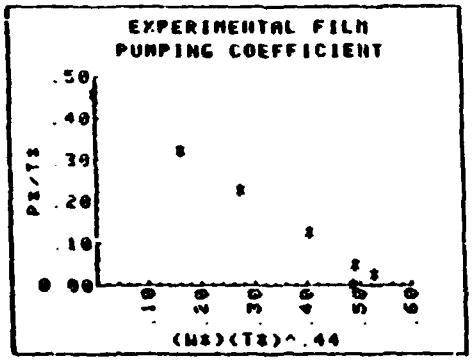
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4245	0.9280	0.4574	0.0000	3.7589	0.0000	181.74	72.70	72.70	0.062
2	0.1693	0.2975	0.9277	0.3207	0.1638	3.7426	0.6335	180.58	83.52	72.24	0.062
3	0.2849	0.2118	0.9287	0.2280	0.2758	3.7611	1.0714	181.13	91.55	72.46	0.062
4	0.4218	0.1165	0.9287	0.1254	0.4082	3.7504	1.5817	180.30	100.32	72.13	0.062
5	0.5082	0.0423	0.9284	0.0456	0.4918	3.7596	1.9105	180.57	106.28	72.24	0.062
6	0.5489	0.0224	0.9284	0.0237	0.5313	3.7504	2.0588	180.06	108.72	72.03	0.061
7	******	0.0007	0.9291	0.0007	******	3.7526	1.0942	180.04	******	72.02	0.061

TABLE 4 - PCD DATA FOR 10/20 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WH	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9280	0.0000	*******	3.759	*******	******
2	******	0.0000	0.9277	0.0000	*******	4.376	*******	******
3	******	0.0000	0.9287	0.0000	*******	4.833	*******	******
4	******	0.0000	0.9267	0.0000	*******	5.332	*******	******
5	******	0.0000	0.9224	0.0000	*******	5.670	*******	******
6	******	0.0000	0.9284	0.0000	*******	5.809	*******	******
7	******	0.0000	0.9291	0.0000	*******	******	*******	******



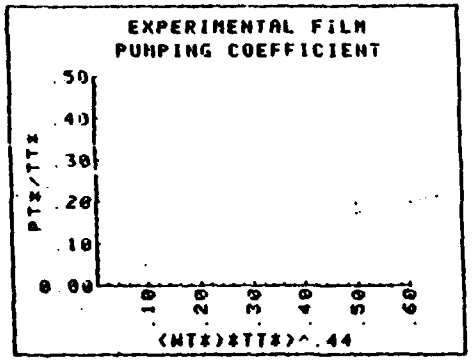


TABLE 4.1 - PCD DATA (CONT) FOR 10/20 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AN/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFACE DIAMETER: 6.902 [IN]
ORIFACE BETA: 0.497 [IN]
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.12 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	58.2	112.0	71.6	3.40	3.08	0.00	0.000	*******
2	0.70	22.0	58.2	112.0	71.6	4.30	2.08	0.00	12.566	*******
3	0.70	21.9	58.0	111.8	71.6	4.90	1.44	0.00	25.133	*******
4	0.70	22.0	58.6	112.0	71.6	5.55	0.77	0.00	50.265	*******
5	0.70	21.9	58.2	112.0	71.8	6.00	0.27	0.00	100.531	*******
6	0.70	22.0	58.4	112.0	71.8	6.15	0.14	0.00	150.796	*******
7	0.70	22.0	57.0	111.8	71.8	6.30	0.01	0.00	*******	*******

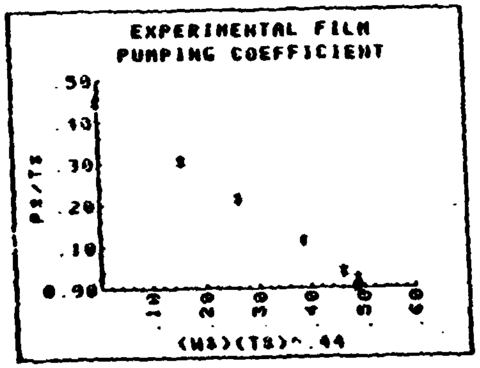
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4154	0.9293	0.4470	0.0000	3.7625	0.0000	181.69	72.68	72.68	0.062
2	0.1646	0.2832	0.9293	0.3047	0.1596	3.7540	0.6187	180.83	83.36	72.34	0.062
3	0.2740	0.1976	0.9297	0.2126	0.2662	3.7462	1.0296	180.11	90.39	72.05	0.061
4	0.4000	0.1049	0.9293	0.1129	0.3873	3.7526	1.5008	180.18	98.82	72.08	0.062
5	0.4760	0.0373	0.9297	0.0401	0.4610	3.7455	1.7830	179.62	103.63	71.86	0.061
6	0.5039	0.0186	0.9297	0.0200	0.4879	3.7533	1.8911	179.94	105.69	71.90	0.061
7	******	0.0007	0.9300	0.0007	******	3.7555	1.8946	179.92	******	71.90	0.061

TABLE 5 - PCD DATA FOR 10/30 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9293	0.0000	*******	3.762	*******	******
2	******	0.0000	0.9293	0.0000	*******	4.373	*******	******
3	******	0.0000	0.9297	0.0000	*******	4.776	*******	******
4	******	0.0000	0.9293	0.0000	*******	5.253	*******	******
5	******	0.0000	0.9297	0.0000	*******	5.528	*******	******
6	******	0.0000	0.9297	0.0000	*******	5.644	*******	******
7	******	0.0000	0.9300	0.0000	*******	******	*******	******



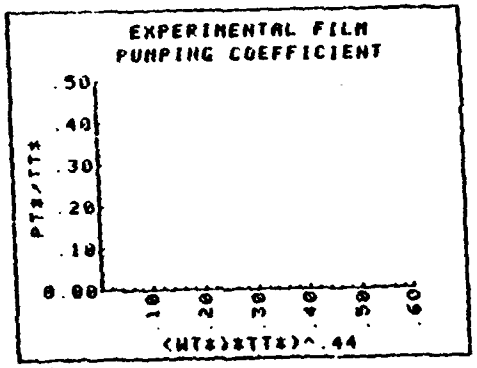


TABLE 5.1 - PCD DATA (CONT) FOR 10/30 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C.DAVIS

NOZZLE AN AP AREA RATIO: 2.50

COMMENTS:
10 TILT 40 ROTATION [MAX]/PCD

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10 [DEG]
ROTATION ANGLE: 40 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.437
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 30.12 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	57.2	111.6	71.8	3.55	2.95	0.00	0.000	*******
2	0.70	22.0	57.8	111.6	71.6	4.45	1.92	0.00	12.566	*******
3	0.70	22.0	57.8	111.8	71.8	5.10	1.31	0.00	25.133	*******
4	0.70	22.1	57.0	111.6	71.8	5.70	0.67	0.00	50.265	*******
5	0.70	22.0	57.4	111.6	71.8	6.10	0.24	0.00	100.531	*******
6	0.70	22.0	57.2	111.6	71.8	6.20	0.12	0.00	150.796	*******
7	0.70	22.0	57.2	111.6	71.8	6.30	0.01	0.00	*******	*******

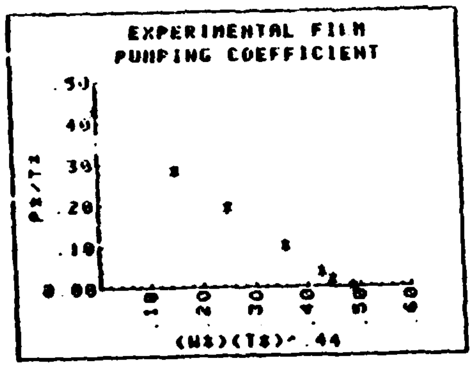
SECONDARY BOX

N	W*	P*	T*	P*/T*	WAT' 44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3374	0.9303	0.4272	0.0000	3.7562	0.0000	181.68	72.68	72.68	0.062
2	0.1531	0.2611	0.9300	0.2808	0.1531	3.7555	0.5936	180.70	82.96	72.29	0.062
3	0.2614	0.1791	0.9300	0.1926	0.2532	3.7554	0.9818	180.50	89.70	72.21	0.062
4	0.3717	0.0909	0.9303	0.0977	0.3601	3.7640	1.3991	180.56	97.16	72.23	0.062
5	0.4428	0.0323	0.9303	0.0347	0.4289	3.7569	1.6674	180.03	101.66	72.02	0.061
6	0.4645	0.0158	0.9303	0.0170	0.4500	3.7576	1.7454	180.01	103.12	72.01	0.061
7	******	0.0007	0.9303	0.0007	******	3.7576	1.8946	179.97	******	71.99	0.661

TABLE 6 - PCD DATA FOR 10/40 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	HT*	PT*	TT*	PT*/TT*	HT*TT .44	HM	HT	VE
RUN						LBM/SEC	LBM SEC	FT/SEC
1	*******	0.0000	0.9303	0.0000	*******	3.766	*******	******
2	*******	0.0000	0.9300	0.0000	*******	4.349	*******	******
3	*******	0.0000	0.9300	0.0000	*******	4.737	*******	******
4	*******	0.0000	0.9303	0.0000	*******	5.163	*******	******
5	*******	0.0000	0.9303	0.0000	*******	5.420	*******	******
6	*******	0.0000	0.9303	0.0000	*******	5.503	*******	******
7	*******	0.0000	0.9303	0.0000	*******	******	*******	******



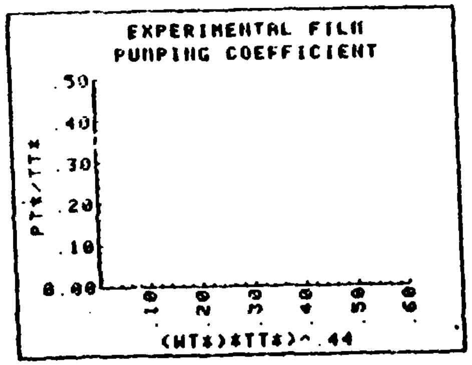


TABLE 6.1 - PCD DATA (CONT) FOR 10/40 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 3 AUG 81
DATA TAKEN BY: C C DAVIS

NOZZLE AM AP AREA RATIO: 2.50

COMMENTS:
15 TILT/00 ROTATION CAL-RUN

MIXING STACK INFORMATION:

LENGTH:	20.48	[IN]
DIAMETER:	11.70	[IN]
L/D RATIO:	1.75	
S/D RATIO:	0.50	

PRIMARY NOZZLE INFORMATION:

TILT ANGLE:	15	[DEG]
ROTATION ANGLE:	0	[DEG]
AREA PER NOZZLE:	10.752	[IN2]
NUMBER OF NOZZLES:	4	

MISCELLANEOUS INFORMATION:

ORIFICE DIAMETER:	6.902	[IN]
ORIFICE BETA:	0.497	
UPTAKE AREA:	107.510	[IN2]
ATM PRESSURE:	30.06	[INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.69	22.0	55.6	107.6	67.0	3.75	3.14	0.00	0.000	*******
2	0.69	22.1	55.9	107.8	67.0	4.40	2.12	0.00	12.566	*******
3	0.69	22.0	55.8	108.2	67.0	4.95	1.48	0.00	25.133	*******
4	0.68	21.9	55.6	108.8	67.0	5.50	0.84	0.00	50.265	*******
5	0.69	22.1	55.6	108.8	67.0	6.05	0.33	0.00	100.531	*******
6	0.69	22.1	55.8	108.8	67.0	6.15	0.19	0.00	150.796	*******
7	0.69	22.0	56.0	109.2	67.0	6.20	0.11	0.00	201.062	*******
8	0.69	22.0	55.8	109.2	67.0	6.25	0.08	0.00	245.044	*******
9	0.69	22.0	56.4	109.4	67.0	6.30	0.01	0.00	*******	*******

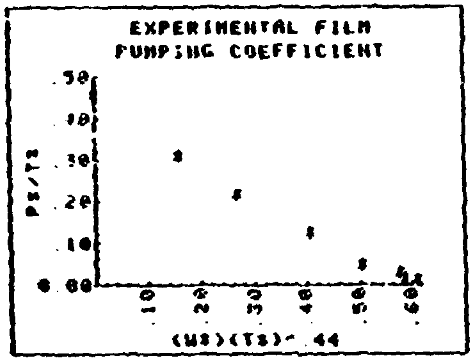
SECONDARY BOX

N	W*	P*	T*	P*/T*	WAT 44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4260	0.9284	0.4589	0.0000	3.7597	0.0000	180.55	72.22	72.23	0.062
2	0.1663	0.2977	0.9231	0.3100	0.1610	3.7675	0.6267	180.53	87.71	72.22	0.062
3	0.2786	0.2031	0.9274	0.2179	0.2695	3.7590	1.0473	179.97	91.53	71.99	0.062
4	0.4207	0.1153	0.9265	0.1245	0.4068	3.7512	1.5780	179.50	99.73	71.81	0.061
5	0.5249	0.0450	0.9265	0.0486	0.5076	3.7683	1.9781	180.09	107.05	72.04	0.062
6	0.5976	0.0259	0.9265	0.0280	0.5778	3.7675	2.2514	180.00	111.85	72.00	0.062
7	0.6070	0.0151	0.9258	0.0163	0.5875	3.7563	2.2841	179.64	112.29	71.86	0.061
8	0.6316	0.0110	0.9258	0.0118	0.6105	3.7590	2.3740	179.67	113.89	71.87	0.061
9	******	0.0014	0.9255	0.0015	******	3.7560	2.6880	179.59	******	71.84	0.061

TABLE 7 - PCD DATA FOR 15/00 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9281	0.0000	*******	3.760	*******	******
2	******	0.0000	0.9281	0.0000	*******	4.394	*******	******
3	******	0.0000	0.9274	0.0000	*******	4.806	*******	******
4	******	0.0000	0.9265	0.0000	*******	5.329	*******	******
5	******	0.0000	0.9265	0.0000	*******	5.746	*******	******
6	******	0.0000	0.9265	0.0000	*******	6.019	*******	******
7	******	0.0000	0.9258	0.0000	*******	6.042	*******	******
8	******	0.0000	0.9258	0.0000	*******	6.133	*******	******
9	******	0.0000	0.9255	0.0000	*******	******	*******	******



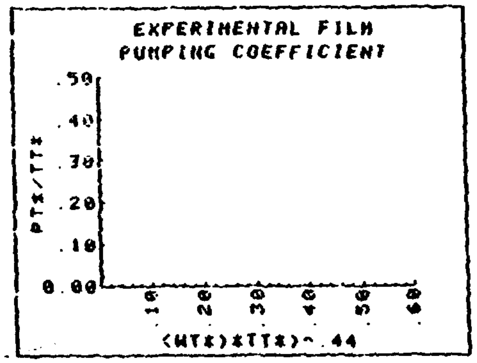


TABLE 7.1 - PCD DATA (CONT) FOR 15/00 NOZZLES WITH L/D=1.75 STACK

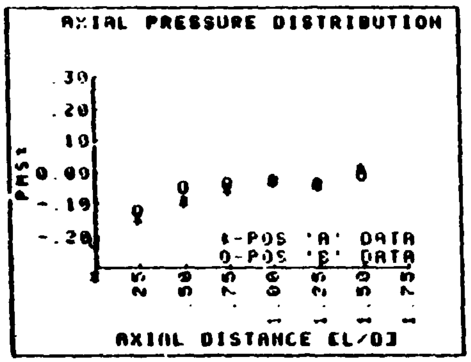
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.330	104	-0.328
0.25	-1.060	38	-0.145
0.50	-0.680	32	-0.093
0.75	-0.330	26	-0.053
1.00	-0.205	22	-0.028
1.25	-0.290	26	-0.040
1.50	0.090	33	0.012

DIAGONAL (POSITION 'B') DATA

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.590	104	-0.218
0.25	-0.870	38	-0.119
0.50	-0.330	32	-0.045
0.75	-0.260	26	-0.036
1.00	-0.165	22	-0.023
1.25	-0.250	26	-0.034
1.50	-0.065	33	-0.009



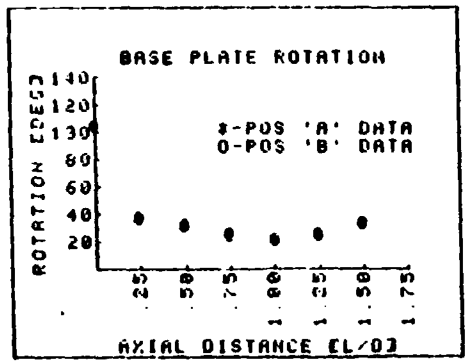
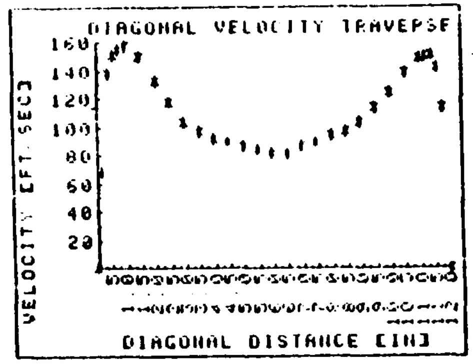


TABLE 7.2 - MSD DATA FOR 15/00 NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	1.50	1.90	2.00	2.10	2.00	2.00
VE[FT/SEC]	0.00	81.45	91.67	94.05	96.37	94.05	94.05
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	1.90	1.90	1.90	2.00	2.00	2.00	1.80
VE[FT/SEC]	91.67	91.67	91.67	94.05	94.05	94.05	89.22
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	9.50
PE[IN H2O]	1.60	1.50	1.50	1.60	1.80	2.00	2.20
VE[FT/SEC]	84.12	81.45	81.45	84.12	89.22	94.05	98.64
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	2.30	2.20	2.20	2.20	2.30	2.40	2.30
VE[FT/SEC]	100.86	96.64	98.64	98.64	100.86	103.03	100.86
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	2.20	1.80	0.20				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	1.05	4.30	5.20	5.40	5.60	5.10
VE[FT/SEC]	0.00	68.15	137.90	151.65	154.54	157.38	150.19
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	4.00	3.10	2.40	2.10	1.90	1.80	1.70
VE[FT/SEC]	133.01	117.09	103.03	96.37	91.67	89.22	86.71
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	1.60	1.50	1.50	1.70	1.80	2.00	2.10
VE[FT/SEC]	84.12	81.45	81.45	86.71	89.22	94.05	96.37
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	2.40	2.90	3.50	4.30	5.00	5.10	5.20
VE[FT/SEC]	103.03	113.25	124.42	137.90	148.71	150.19	151.65
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	4.60	2.90	0.00				

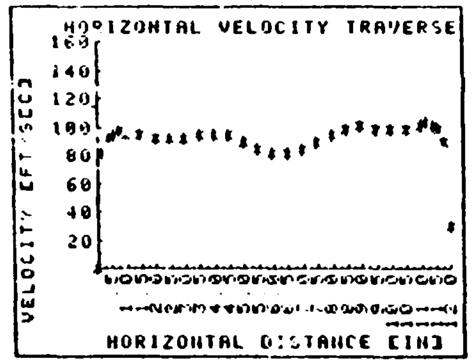


TABLE 7.3 - VTD DATA FOR 15/00 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 5 AUG 81
DATA TAKEN BY: C C. DAVIS

NOZZLE AN/AP AREA RATIO: 2.50

COMMENTS:
COMPARISON OF ROTATION ANGLES

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 0 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.08 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.69	22.0	53.2	107.2	67.2	6.25	0.01	0.00	*******	*******

SECONDARY BOX

N	WS	PS	TS	PS/TS	WST^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	******	0.0007	0.9294	0.0007	******	3.7698	1.9016	179.39	******	71.76	0.061

TERTIARY BOX

N	WTS	PTS	TTS	PTS/TTS	WTSTT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9294	0.0000	*******	******	*******	******

TABLE 8 – PCD DATA FOR 15/00 NOZZLES WITH L/D=1.75 MSD COMPARISON BASE PLATE FIXED AT 00 ROTATION

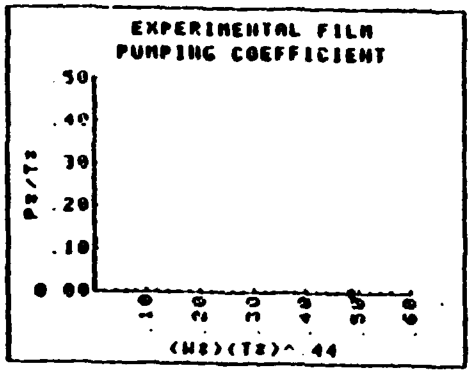
MIXING STACK DATA FOR RUN 1

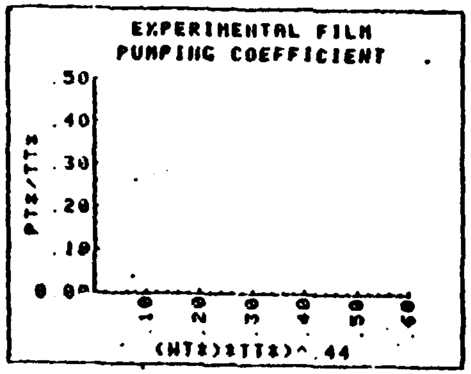
TOP (POSITION 'A') DATA

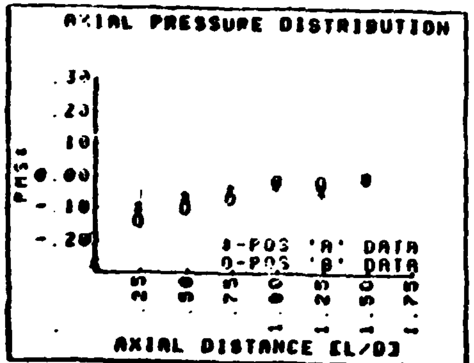
X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.995	0	-0.274
0.25	-0.735	0	-0.101
0.50	-0.485	0	-0.067
0.75	-0.305	0	-0.042
1.00	-0.195	0	-0.027
1.25	-0.305	0	-0.042
1.50	0.015	0	0.002

DIAGONAL (POSITION 'B') DATA

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.415	0	-0.194
0.25	-0.995	0	-0.137
0.50	-0.705	0	-0.097
0.75	-0.470	0	-0.065
1.00	-0.115	0	-0.016
1.25	-0.100	0	-0.014
1.50	-0.005	0	-0.001







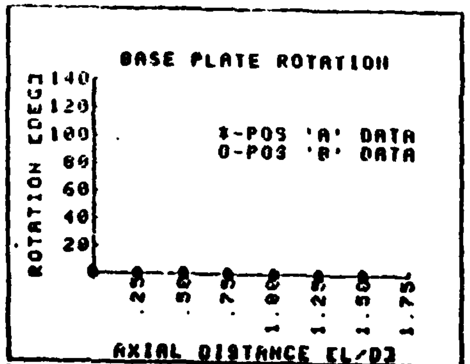


TABLE 8.1 - MSD DATA FOR 15/00 NOZZLES WITH L/D=1.75 MSD COMPARISON BASE PLATE FIXED AT 00 ROTATION

DATA TAKEN ON: 5 AUG 81
DATA TAKEN BY: C C DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
COMPARISON OF ROTATION ANGLES

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 0 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.00 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.69	22.0	53.1	107.3	67.4	6.25	0.01	0.00	*******	*******

SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	******	0.0007	0.9296	0.0007	******	3.7702	1.9012	179.44	******	71.78	0.062

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.92[illegible]	0.0000	*******	******	*******	******

TABLE 9 - PCD DATA FOR 15/00 NOZZLES WITH L/D=1.75 MSD COMPARISON
BASE PLATE ROTATED TO FIRST PEAK ONLY

MIXING STACK DATA FOR RUN 1

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-2.330	13	-0.327
0.25	-0.995	13	-0.137
0.50	-0.615	13	-9.084
0.75	-0.425	13	-0.058
1.00	-0.235	13	-0.032
1.25	-0.145	13	-0.028
1.50	0.015	13	0.002

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-1.650	13	-0.227
0.25	-0.870	13	-0.120
0.50	-0.605	13	-0.083
0.75	-0.295	13	-0.041
1.00	-0.075	13	-0.010
1.25	-0.180	13	-0.025
1.50	-0.065	13	-0.009

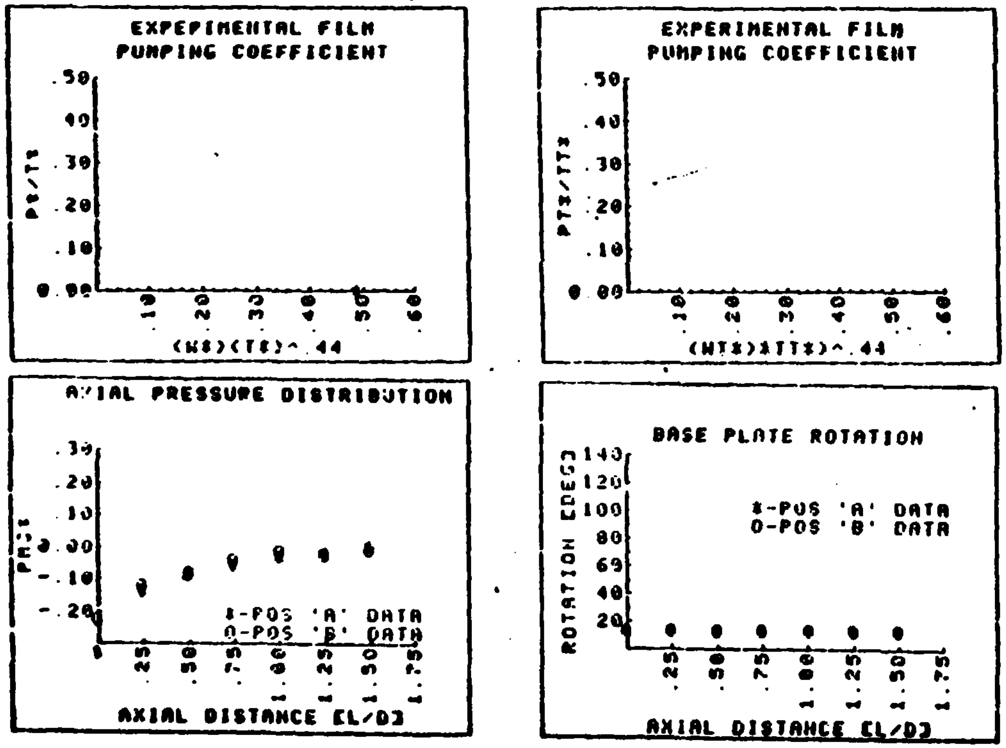


TABLE 9.1 - MSD DATA FOR 15/10 NOZZLES WITH L/D=1.75 MSD COMPARISON
BASE PLATE ROTATED TO FIRST PEAK ONLY

DATA TAKEN ON: 5 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AN AP AREA RATIO: 2.50

COMMENTS:
COMPARISON OF ROTATION ANGLES

MIXING STACK INFORMATION:
LENGTH 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 0 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 30.08 [INHG]

N	POR	UPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES	F		IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.69	22.0	53.0	107.4	67.6	6.25	0.01	0.00	*******	*******

SECONDARY BOX

N	WS	PS	TS	PS/TS	WST^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	******	0.0007	0.9290	0.0007	******	3.7705	1.3000	179.49	******	71.00	0.062

TERTIARY BOX

N	WTS	PTS	TTS	PTS/TTS	WTSTT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9290	0.0000	*******	******	*******	******

TABLE 10 - PCD DATA FOR 15/00 NOZZLES WITH L/D=1.75 MSD COMPARISON BASE PLATE ROTATED FOR PEAKS AT EACH X/D POSITION

MIXING STACK DATA FOR RUN 1

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.50	-2.390	103	-0.327
0.25	-1.145	36	-0.157
0.50	-0.595	32	-0.094
0.75	-0.395	25	-0.054
1.00	-0.195	22	-0.027
1.25	-0.200	24	-0.030
1.50	0.155	32	0.021

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-1.595	103	-0.219
0.25	-0.605	36	-0.033
0.50	-0.355	32	-0.049
0.75	-0.215	25	-0.030
1.00	-0.095	22	-0.013
1.25	-0.250	24	-0.034
1.50	-0.070	32	-0.010

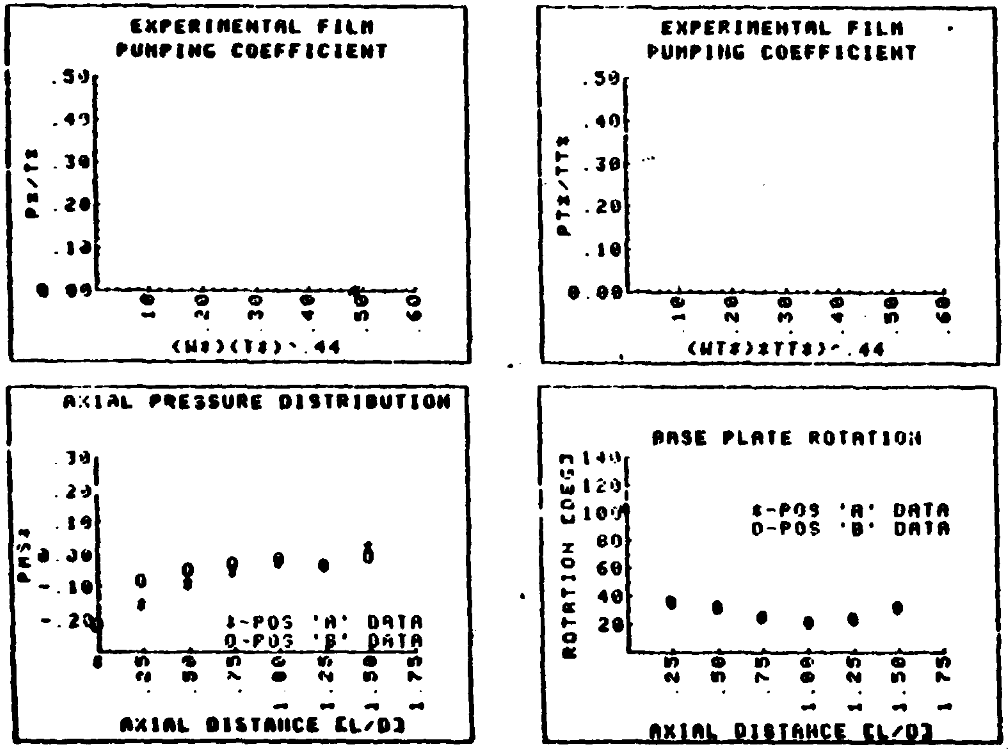


TABLE 10.1 - MSD DATA FOR 15/00 NOZZLES WITH L/D=1.75 MSD COMPARISON
BASE PLATED ROTATED FOR PEAKS AT EACH X/D POSITION

DATA TAKEN ON: 10 AUG 81
DATA TAKEN BY: C. C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/10 ROTATION NOZZLES

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.12 [INHG]

N	POR	DFOP	TOP	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.2	57.0	111.0	71.4	3.45	3.10	0.00	0.000	*******
2	0.70	22.1	57.2	111.0	71.4	4.25	2.21	0.00	12.566	*******
3	0.70	22.0	56.4	110.8	71.6	4.80	1.57	0.00	25.133	*******
4	0.70	22.1	56.4	110.4	71.6	5.45	0.88	0.00	50.265	*******
5	0.70	22.0	56.0	110.2	71.0	5.95	0.35	0.00	100.531	*******
6	0.70	22.0	56.0	110.2	71.0	6.05	0.19	0.00	150.796	*******
7	0.70	22.0	56.2	110.2	72.2	6.15	0.11	0.00	201.062	*******
8	0.70	22.0	56.2	110.2	72.2	5.20	0.07	0.00	245.044	*******
9	0.70	22.0	56.0	110.4	72.4	6.25	0.00	0.00	*******	*******

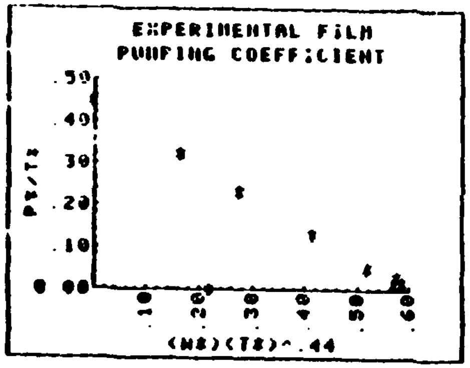
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4165	0.9306	0.4476	0.0000	3.7754	0.0000	192.00	72.81	72.81	0.062
2	0.1634	0.2997	0.9306	0.3221	0.1611	3.7662	0.6379	181.16	83.83	72.47	0.062
3	0.2859	0.2145	0.9313	0.2303	0.2771	3.7605	1.0751	180.54	91.38	72.22	0.062
4	0.4271	0.1202	0.9319	0.1290	0.4140	3.7691	1.6097	180.52	100.89	72.21	0.062
5	0.5357	0.0475	0.9326	0.0509	0.5195	3.7620	2.0154	179.88	107.68	71.96	0.061
6	0.5964	0.0262	0.9326	0.0281	0.5783	3.7620	2.2435	179.81	111.92	71.93	0.061
7	0.6049	0.0152	0.9333	0.0163	0.5866	3.7613	2.2752	179.74	112.48	71.90	0.061
8	0.5881	0.0097	0.9333	0.0103	0.5705	3.7613	2.2120	179.73	111.35	71.90	0.061
9	******	0.0001	0.9333	0.0001	******	3.7591	0.0460	179.66	******	71.87	0.061

TABLE 11 - PCD DATA FOR 15/10 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9306	0.0000	*******	3.775	*******	******
2	******	0.0000	0.9306	0.0000	*******	4.404	*******	******
3	******	0.0000	0.9313	0.0000	*******	4.836	*******	******
4	******	0.0000	0.9319	0.0000	*******	5.379	*******	******
5	******	0.0000	0.9326	0.0000	*******	5.777	*******	******
6	******	0.0000	0.9326	0.0000	*******	6.005	*******	******
7	******	0.0000	0.9333	0.0000	*******	6.036	*******	******
8	******	0.0000	0.9333	0.0000	*******	5.973	*******	******
9	******	0.0000	0.9333	0.0000	*******	******	*******	******



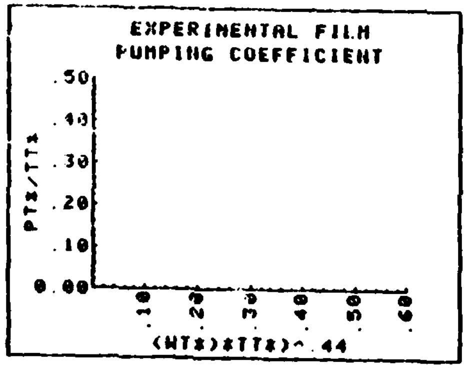


TABLE 11.1 - PCD DATA (CONT) FOR 15/10 NOZZLES WITH L/D=1.75.

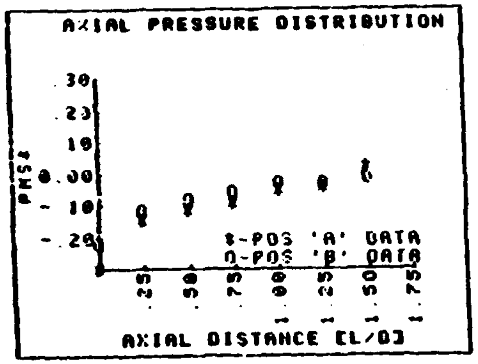
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS#
0.00	-2.160	96	-0.298
0.25	-1.040	34	-0.144
0.50	-0.835	29	-0.115
0.75	-0.655	27	-0.090
1.00	-0.385	32	-0.053
1.25	-0.315	36	-0.044
1.50	0.145	38	0.020

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS#
0.00	-1.595	96	-0.220
0.25	-0.845	34	-0.117
0.50	-0.585	29	-0.[illegible]
0.75	-0.445	27	-0.061
1.00	-0.225	32	-0.031
1.25	-0.235	36	-0.032
1.50	-0.100	38	-0.014



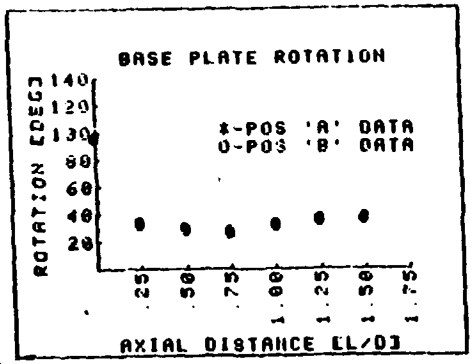
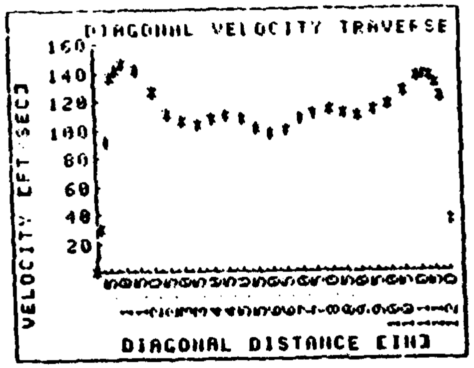


TABLE 11.2 - MSD DATA FOR 15/10 NOZZLES WITH L/D=1.75

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 07 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]:	0.00	1.40	1.70	1.70	1.80	1.70	1.60
V[FT/SEC]:	0.00	79.01	87.07	87.07	89.59	87.07	84.47
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]:	1.70	1.90	2.30	2.60	2.80	2.70	2.50
V[FT/SEC]:	87.07	92.05	101.27	107.67	111.74	109.73	105.58
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]:	2.10	2.00	2.10	2.50	2.80	2.90	3.00
V[FT/SEC]:	96.77	94.44	96.77	105.58	111.74	113.72	115.66
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]:	2.60	2.40	1.90	1.80	1.90	1.90	1.80
V[FT/SEC]:	107.67	103.45	92.05	89.59	92.05	92.05	89.59
POSIT[IN]:	11.60	11.80	12.00				
P[IN H2O]:	1.60	1.20	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 07 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]:	0.00	0.20	1.90	4.20	4.50	4.80	4.50
V[FT/SEC]:	0.00	23.86	92.05	136.35	141.65	146.30	141.65
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]:	3.60	2.80	2.50	2.40	2.60	2.70	2.60
V[FT/SEC]:	126.79	111.74	105.58	103.45	107.67	109.73	107.67
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]:	2.30	2.10	2.20	2.60	2.80	2.90	2.80
V[FT/SEC]:	101.27	96.77	99.05	107.67	111.74	113.72	111.74
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]:	2.70	2.90	3.10	3.60	4.20	4.30	4.20
V[FT/SEC]:	109.73	113.72	117.57	126.70	136.85	136.47	136.85
POSIT[IN]:	11.60	11.80	12.00				
P[IN H2O]:	3.90	3.40	0.30				

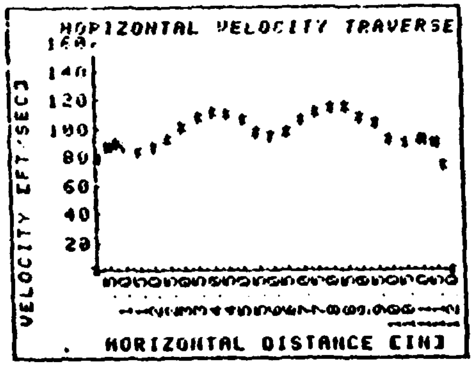


TABLE 11.3 - VTD DATA FOR 15/10 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 10 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/20 ROTATION NOZZLES

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.12 [INHG]

N RUN	POR IN OF H2O	DPOR IN OF H2O	TOR DEGREES F	TUPT DEGREES F	TAMB DEGREES F	PUPT IN OF H2O	PSEC IN OF H2O	PTER IN OF H2O	SECONDARY AREA SQUARE INCHES	TERTIARY AREA SQUARE INCHES
1	0.69	22.0	56.2	110.6	72.0	3.25	3.11	0.00	0.000	*******
2	0.69	21.9	56.6	110.8	72.2	4.15	2.22	0.00	12.566	*******
3	0.70	22.0	55.0	110.4	72.6	4.80	1.62	0.00	25.133	*******
4	0.70	22.0	55.0	110.0	72.4	5.40	0.94	0.00	50.265	*******
5	0.69	22.0	55.6	110.2	72.4	5.95	0.34	0.00	100.531	*******
6	0.69	22.0	55.2	110.2	72.4	6.15	0.22	0.00	150.796	*******
7	0.70	22.0	55.0	110.2	72.4	6.20	0.16	0.00	201.062	*******
8	0.70	22.0	55.4	110.2	72.4	6.25	0.12	0.00	245.044	*******
9	0.70	22.0	56.2	110.4	72.4	6.30	0.00	0.00	*******	

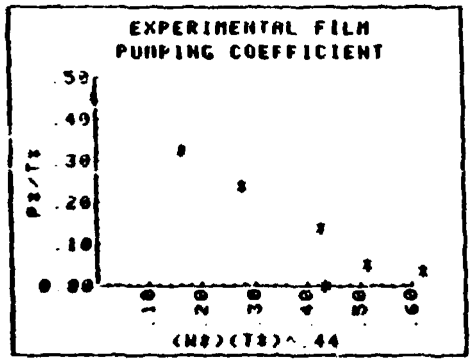
SECONDARY BOX

N RUN	W*	P*	T*	P*/T* W*T^.44	WP LBM/SEC	WS LBM/SEC	UP FT/SEC	UM FT/SEC	UUPT FT/SEC	UPT MACH
1	0.0000	0.4221	0.9323	0.4527	0.0000	3.7613	0.0000	181.20	72.48	72.49	0.062
2	0.1703	0.3041	0.9323	0.3262	0.1651	3.7513	0.6338	180.39	83.55	72.16	0.062
3	0.2997	0.2214	0.9337	0.2371	0.2811	3.7656	1.0910	180.68	91.75	72.28	0.062
4	0.4403	0.1283	0.9340	0.1374	0.4273	3.7656	1.6580	180.25	101.69	72.11	0.062
5	0.5313	0.0468	0.9337	0.0501	0.5155	3.7635	1.9996	179.95	107.67	71.99	0.062
6	0.6408	0.0303	0.9337	0.0324	0.6218	3.7650	2.4128	179.97	115.04	71.99	0.062
7	0.7171	0.0213	0.9337	0.0229	0.6957	3.7657	2.7003	179.97	120.18	72.00	0.062
8	0.7531	0.0150	0.9337	0.0170	0.7307	3.7642	2.8347	179.89	122.54	71.96	0.061
9	******	0.0006	0.9333	0.0006	******	3.7613	1.6936	179.76	******	71.91	0.061

TABLE 12 - PCD DATA FOR 15/20 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9323	0.0000	*******	3.761	*******	******
2	******	0.0000	0.9323	0.0000	*******	4.390	*******	******
3	******	0.0000	0.9337	0.0000	*******	4.857	*******	******
4	******	0.0000	0.9340	0.0000	*******	5.424	*******	******
5	******	0.0000	0.9337	0.0000	*******	5.763	*******	******
6	******	0.0000	0.9337	0.0000	*******	6.178	*******	******
7	******	0.0000	0.9337	0.0000	*******	6.466	*******	******
8	******	0.0000	0.9337	0.0000	*******	6.599	*******	******
9	******	0.0000	0.9333	0.0000	*******	******	*******	******



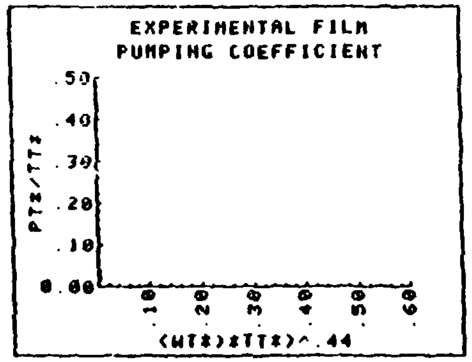


TABLE 12.1 - PCD DATA (CONT) FOR 15/20 NOZZLES WITH L/D=1.75 STACK

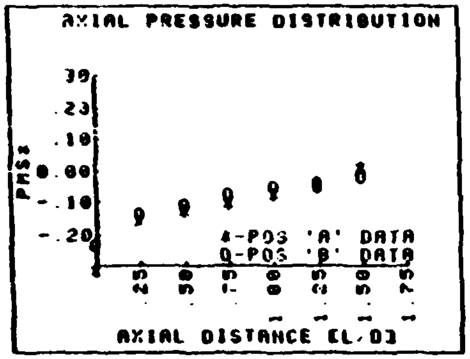
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.270	92	-0.313
0.25	-1.150	30	-0.159
0.50	-0.935	26	-0.129
0.75	-0.765	24	-0.106
1.00	-0.530	24	-0.073
1.25	-0.375	25	-0.052
1.50	0.075	24	0.010

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.710	92	-0.236
0.25	-1.010	30	-0.139
0.50	-0.790	26	-0.109
0.75	-0.565	24	-0.078
1.00	-0.385	24	-0.053
1.25	-0.315	25	-0.043
1.50	-0.150	24	-0.021



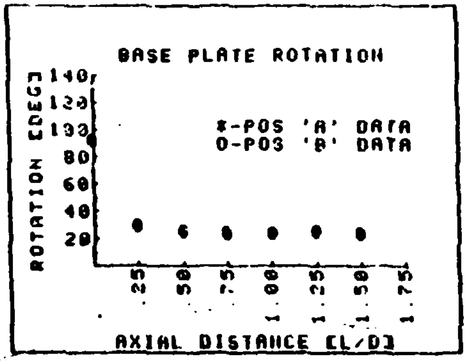
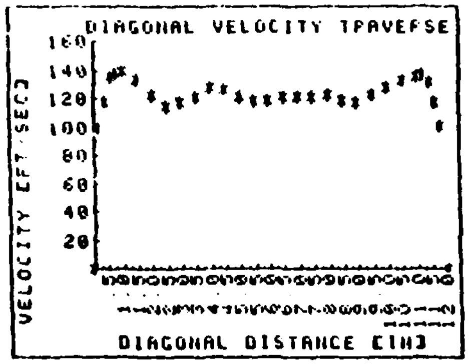


TABLE 12.2 - MSD DATA FOR 15/20 NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 05 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	0.80	1.10	1.20	1.30	1.20	1.30
V[FT/SEC]	0.00	59.73	70.04	73.15	76.14	73.15	76.14
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	1.50	2.20	3.00	3.50	3.80	3.70	3.30
V[FT/SEC]	91.77	99.05	115.66	124.93	130.17	128.15	121.31
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.10	3.00	3.10	3.30	3.40	3.30	2.70
V[FT/SEC]	117.57	115.66	117.57	121.31	123.13	121.31	199.73
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	2.10	1.60	1.60	1.50	1.60	1.50	1.50
V[FT/SEC]	96.77	89.59	84.47	81.78	84.47	81.78	81.78
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	1.30	0.90	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 05 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	2.20	3.10	4.10	4.30	4.40	4.00
V[FT/SEC]	0.00	99.05	117.57	135.21	139.47	140.07	133.55
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	3.40	3.00	3.10	3.30	3.70	3.60	3.30
V[FT/SEC]	123.17	115.66	117.57	121.31	128.45	126.70	121.31
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.20	3.20	3.30	3.30	3.30	3.40	3.20
V[FT/SEC]	119.45	119.45	121.31	121.31	121.31	123.13	119.45
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	3.10	3.40	3.70	4.00	4.10	4.20	3.90
V[FT/SEC]	117.57	123.13	128.45	133.55	135.21	136.85	131.87
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	3.10	2.30	0.00				

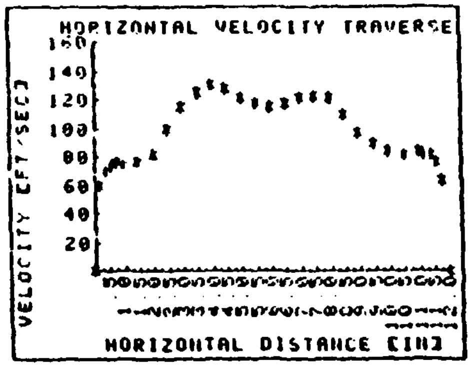


TABLE 12.3 - VTD DATA FOR 15/20 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 18 AUG 81
DATA TAKEN BY: C C. DAVIS

NOZZLE AN/AP AREA RATIO: 2.50

COMMENTS:
15 TILT 25 ROTATION/.5 S/D RATIO

MIXING STACK INFORMATION:
LENGTH: 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 25 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 29.92 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	57.2	110.6	68.6	3.25	3.10	0.00	0.000	*******
2	0.70	22.0	57.2	110.6	63.6	4.15	2.21	0.00	12.566	*******
3	0.69	22.0	57.8	110.6	69.2	4.70	1.59	0.00	25.133	*******
4	0.70	22.1	57.2	110.6	70.2	5.45	0.89	0.00	50.265	*******
5	0.70	22.1	58.6	111.2	70.6	5.95	0.34	0.00	100.531	*******
6	0.70	22.0	56.6	111.4	70.6	6.10	0.19	0.00	150.796	*******
7	0.70	22.0	58.0	111.2	70.6	6.15	0.13	0.00	201.062	*******
8	0.70	22.0	58.2	111.4	70.6	6.25	0.07	0.00	245.044	*******
9	0.70	22.0	58.0	111.2	70.0	6.30	0.03	0.00	*******	*******

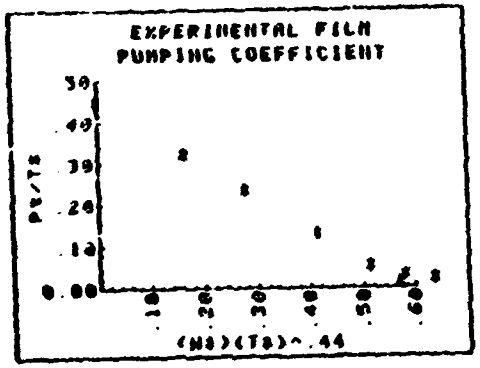
SECONDARY BOX

N	N*	P*	T*	P*/T*	N*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4169	0.9264	0.4501	0.0000	3.7536	0.0000	182.04	72.82	72.82	0.062
2	0.1702	0.2999	0.9264	0.3237	0.1646	3.7451	0.6374	181.23	83.86	72.50	0.062
3	0.2887	0.2169	0.9274	0.2339	0.2793	3.7430	1.0807	180.85	91.64	72.35	0.062
4	0.4304	0.1214	0.9292	0.1306	0.4167	3.7536	1.6156	181.05	101.33	72.43	0.062
5	0.5326	0.0466	0.9289	0.0501	0.5156	3.7485	1.9964	180.75	108.04	72.31	0.062
6	0.5985	0.0261	0.9286	0.0281	0.5793	3.7401	2.2386	180.34	112.22	72.14	0.062
7	0.6597	0.0179	0.9269	0.0192	0.6367	3.7422	2.4689	180.35	116.34	72.15	0.062
8	0.5901	0.0096	0.9286	0.0104	0.5712	3.7415	2.2088	180.36	111.67	72.15	0.062
9	******	0.0041	0.9292	0.0044	******	3.7422	4.6297	180.31	******	72.13	0.062

TABLE 13 - PCD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9264	0.0000	*******	3.754	*******	******
2	******	0.0000	0.9264	0.0000	*******	4.383	*******	******
3	******	0.0000	0.9274	0.0000	*******	4.824	*******	******
4	******	0.0000	0.9292	0.0000	*******	5.369	*******	******
5	******	0.0000	0.9289	0.0000	*******	5.745	*******	******
6	******	0.0000	0.9286	0.0000	*******	5.979	*******	******
7	******	0.0000	0.9289	0.0000	*******	6.211	*******	******
8	******	0.0000	0.9286	0.0000	*******	5.949	*******	******
9	******	0.0000	0.9292	0.0000	*******	******	*******	******



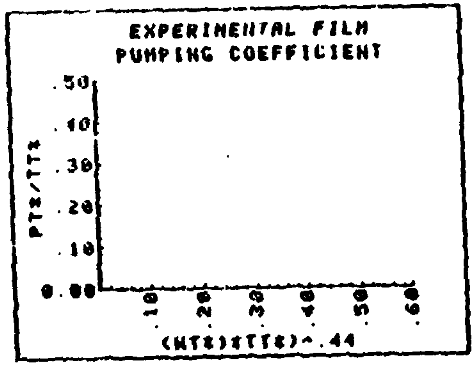


TABLE 13.1 - PCD DATA (CONT) FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=Ø.5 STACK

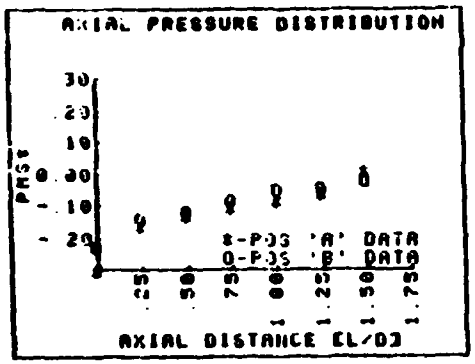
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-2.200	92	-0.303
0.25	-1.230	28	-0.169
0.50	-0.970	24	-0.134
0.75	-0.810	16	-0.112
1.00	-0.620	18	-0.085
1.25	-0.455	19	-0.063
1.50	0.045	20	0.006

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-1.690	92	-0.233
0.25	-1.030	28	-0.142
0.50	-0.850	24	-0.121
0.75	-0.615	16	-0.085
1.00	-0.405	18	-0.056
1.25	-0.335	19	-0.046
1.50	-0.185	20	-0.025



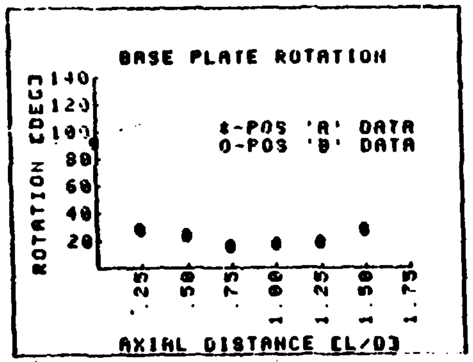
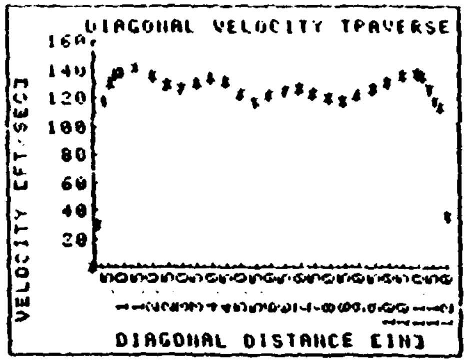


TABLE 13.2 - MSD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.5 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 84 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	1.00	1.30	1.40	1.40	1.50	1.30
V[FT/SEC]	0.00	66.90	76.28	79.16	79.16	81.93	76.23
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	1.40	1.70	2.60	3.50	4.10	4.00	3.70
V[FT/SEC]	79.15	87.23	107.87	125.16	135.46	133.89	128.68
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.10	3.20	3.50	3.80	3.70	3.60	2.80
V[FT/SEC]	117.79	119.67	125.16	130.41	128.68	126.93	111.94
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	2.20	1.60	1.50	1.50	1.60	1.70	1.70
V[FT/SEC]	99.23	64.62	81.93	81.93	84.62	87.23	87.23
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	1.40	0.90	0.10				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 84 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	0.20	3.10	3.80	4.20	4.30	4.40
V[FT/SEC]	0.00	29.92	117.79	130.41	137.10	138.72	140.33
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	4.10	3.79	3.60	3.80	4.00	3.90	3.40
V[FT/SEC]	135.46	128.68	126.93	130.41	133.80	132.11	123.36
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.10	3.30	3.50	3.60	3.40	3.20	3.10
V[FT/SEC]	117.79	121.53	125.16	126.93	123.36	119.67	117.79
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	3.30	3.60	3.80	4.10	4.20	4.10	3.60
V[FT/SEC]	121.53	126.93	130.41	135.46	137.10	135.46	126.93
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	3.10	2.90	0.30				

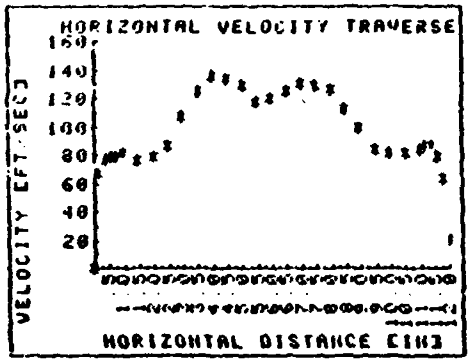


TABLE 13.3 - VTD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.5 STACK

DATA TAKEN ON: 12 AUG 91
DATA TAKEN BY: DAVIS/DRUCKER

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/25 ROTATE/.4 S/D RATIO

MIXING STACK INFORMATION:		PRIMARY NOZZLE INFORMATION:		MISCELLANEOUS INFORMATION:	
LENGTH:	20.48 [IN]	TILT ANGLE:	15 [DEG]	ORIFICE DIAMETER:	6.902 [IN]
DIAMETER:	11.70 [IN]	ROTATION ANGLE:	25 [DEG]	ORIFICE BETA:	0.497
L/D RATIO:	1.75	AREA PER NOZZLE:	10.752 [IN2]	UPTAKE AREA:	107.510 [IN2]
S/D RATIO:	0.40	NUMBER OF NOZZLES:	4	ATM PRESSURE:	29.94 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	56.2	110.0	68.0	3.25	3.13	0.00	0.000	*******
2	0.70	22.0	56.2	110.0	68.2	4.10	2.23	0.00	12.566	*******
3	0.70	22.0	56.4	110.0	69.0	4.75	1.61	0.00	25.133	*******
4	0.70	22.1	56.0	110.2	69.4	5.40	0.90	0.00	50.265	*******
5	0.69	22.0	57.0	110.4	69.4	5.90	0.34	0.00	100.531	*******
6	0.70	22.0	56.4	110.4	69.6	6.05	0.19	0.00	150.796	*******
7	0.70	22.0	56.8	110.4	70.0	6.10	0.12	0.00	201.062	*******
8	0.70	22.0	56.8	110.4	70.0	6.15	0.08	0.00	245.044	*******
9	0.70	22.0	56.6	110.4	70.0	6.20	0.02	0.00	*******	*******

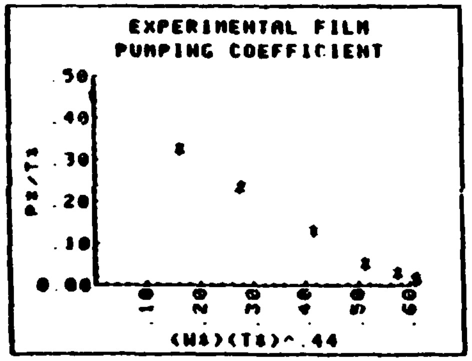
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4205	0.9263	0.4540	0.0000	3.7582	0.0000	181.99	72.80	72.60	0.062
2	0.1709	0.3024	0.9266	0.3263	0.1652	3.7497	0.6407	181.18	83.89	72.48	0.062
3	0.2902	0.2194	0.9280	0.2364	0.2808	3.7489	1.0880	180.87	91.76	72.35	0.062
4	0.4330	0.1226	0.9284	0.1321	0.4191	3.7560	1.6263	180.95	101.42	72.39	0.062
5	0.5336	0.0466	0.9281	0.0503	0.5163	3.7468	1.9991	180.32	107.82	72.14	0.062
6	0.5976	0.0261	0.9264	0.0281	0.5786	3.7489	2.2412	180.36	112.18	72.15	0.062
7	0.6335	0.0165	0.9291	0.0178	0.6133	3.7475	2.3740	180.26	114.54	72.11	0.062
8	0.6304	0.0110	0.9291	0.0118	0.6103	3.7475	2.3624	180.24	114.32	72.10	0.062
9	******	0.0027	0.9291	0.0030	******	3.7402	3.7039	180.25	******	72.11	0.062

TABLE 14 - PCD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.4 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9263	0.0000	*******	3.758	*******	******
2	******	0.0000	0.9266	0.0000	*******	4.390	*******	******
3	******	0.0000	0.9280	0.0000	*******	4.837	*******	******
4	******	0.0000	0.9264	0.0000	*******	5.382	*******	******
5	******	0.0000	0.9261	0.0000	*******	5.746	*******	******
6	******	0.0000	0.3284	0.0000	*******	5.990	*******	******
7	******	0.0000	0.9291	0.0000	*******	6.121	*******	******
8	******	0.0000	0.9291	0.0000	*******	6.110	*******	******
9	******	0.0000	0.9291	0.0000	*******	******	*******	******



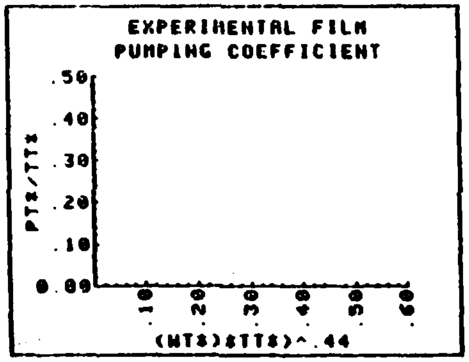


TABLE 14.1 - PCD DATA (CONT) FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=Ø.4 STACK

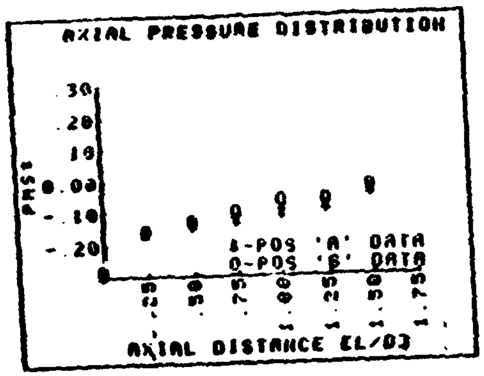
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-2.110	115	-0.290
0.25	-1.210	24	-0.166
0.50	-1.010	20	-0.139
0.75	-0.910	18	-0.125
1.00	-0.770	20	-0.106
1.25	-0.605	24	-0.083
1.50	-0.256	14	-0.034

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-2.060	115	-0.283
0.25	-1.150	24	-0.158
0.50	-0.930	20	-0.128
0.75	-0.705	18	-0.097
1.00	-0.465	20	-0.064
1.25	-0.415	24	-0.057
1.50	-0.145	14	-0.020



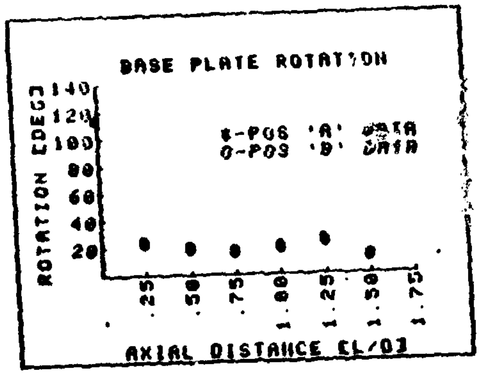
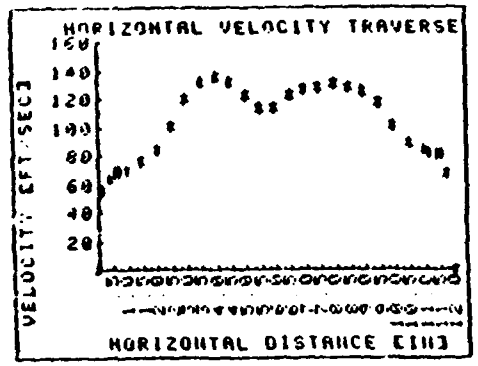


TABLE 14.2 - MSD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.4 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 90 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	0.70	0.90	1.00	1.10	1.10	1.30
V[FT/SEC]	0.00	55.92	63.40	66.83	70.09	70.09	76.20
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	1.60	2.30	3.20	3.90	4.10	3.90	3.40
V[FT/SEC]	84.54	101.36	119.55	131.98	135.32	131.98	123.23
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	2.90	2.90	3.40	3.60	3.70	3.80	3.70
V[FT/SEC]	113.81	113.81	123.23	126.80	128.55	130.28	128.55
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	3.50	3.10	2.30	1.80	1.60	1.50	1.50
V[FT/SEC]	125.03	117.67	101.36	89.66	84.54	81.85	81.85
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	1.50	1.00	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 90 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	0.50	3.70	4.30	4.50	4.70	4.20
V[FT/SEC]	0.00	47.26	128.55	138.59	141.77	144.89	136.96
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	3.60	3.40	3.30	4.10	4.20	3.90	3.30
V[FT/SEC]	126.80	123.23	121.41	135.32	136.96	131.98	121.41
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	2.80	2.90	3.50	3.90	3.80	3.50	2.90
V[FT/SEC]	111.83	113.81	125.03	131.98	130.28	125.03	113.81
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	2.60	2.70	3.30	4.00	4.20	4.10	3.90
V[FT/SEC]	107.76	109.82	121.41	133.66	136.96	135.32	131.98
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	3.40	2.50	0.00				

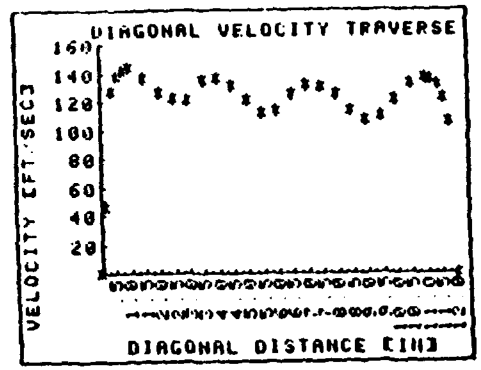


TABLE 14.3 - VTD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.4 STACK

DATA TAKEN ON: 13 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/25 ROTATE/0.25 S/D RATIO

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.25

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 25 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	57.2	110.0	69.0	3.25	3.11	0.00	0.000	*******
2	0.71	22.0	57.6	111.0	68.0	4.10	2.21	0.00	12.566	*******
3	0.70	22.0	57.0	111.0	69.2	4.65	1.57	0.00	25.133	*******
4	0.70	22.0	58.0	111.4	69.4	5.35	0.83	0.00	50.265	*******
5	0.70	22.1	58.2	111.0	69.4	5.85	0.29	0.00	100.531	*******
6	0.70	22.2	58.2	112.0	70.0	5.95	0.16	0.00	150.796	*******
7	0.70	22.2	58.2	111.0	70.2	6.10	0.02	0.00	*******	*******

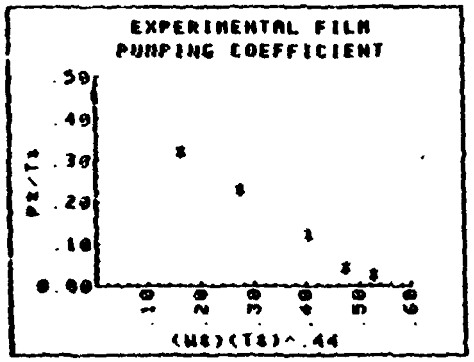
SECONDARY BOX

N	W*	P*	T*	P*/T* W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN					LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4202	0.9267	0.4534	0.0000	3.7495	0.0000	181.48	72.60	72.60	0.062
2	0.1702	0.2993	0.9261	0.3238	0.1646	3.7480	0.6380	181.07	83.79	72.44	0.062
3	0.2869	0.2139	0.9268	0.2308	0.2775	3.7473	1.0752	180.75	91.46	72.31	0.062
4	0.4172	0.1134	0.9265	0.1224	0.4034	3.7466	1.5632	180.52	100.07	72.21	0.062
5	0.4922	0.0395	0.9258	0.0427	0.4756	3.7544	1.8480	180.78	105.25	72.32	0.062
6	0.5469	0.0217	0.9265	0.0235	0.5280	3.7629	2.0578	181.19	109.19	72.48	0.062
7	******	0.0027	0.9272	0.0029	******	3.7629	3.7067	181.07	******	72.43	0.062

TABLE 15 - PCD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	######	0.0000	0.9267	0.0000	#######	3.749	#######	######
2	######	0.0000	0.9261	0.0003	#######	4.386	#######	######
3	######	0.0000	0.9260	0.0000	#######	4.822	#######	######
4	######	0.0000	0.9265	0.0000	#######	5.310	#######	######
5	######	0.0000	0.9250	0.0000	#######	5.602	#######	######
6	######	0.0000	0.9265	0.0000	#######	5.821	#######	######
7	######	0.0000	0.9272	0.0000	#######	######	#######	######



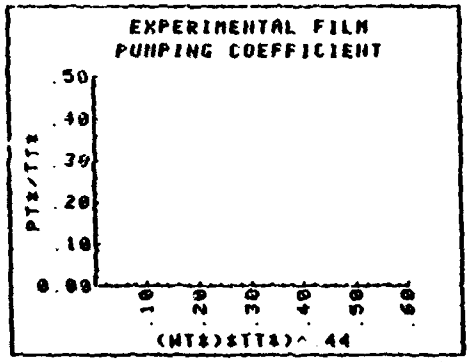


TABLE 15.1 - PCD DATA (CONT) FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.25 STACK

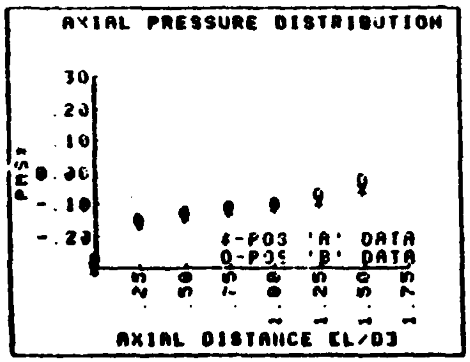
MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-2.220	92	-0.302
0.25	-1.200	28	-0.163
0.50	-1.040	14	-0.141
0.75	-0.910	26	-0.124
1.00	-0.790	32	-0.107
1.25	-0.675	34	-0.092
1.50	-0.395	20	-0.054

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-1.970	92	-0.268
0.25	-1.120	28	-0.152
0.50	-0.950	14	-0.129
0.75	-0.815	26	-0.111
1.00	-0.705	32	-0.096
1.25	-0.520	34	-0.071
1.50	-0.170	20	-0.023



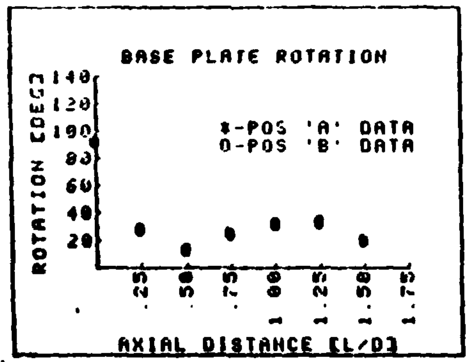
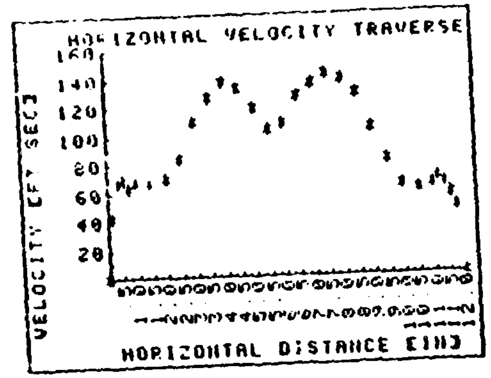


TABLE 15.2 - MSD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.25 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 02 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.40	1.00	1.10	0.90	1.00	1.00
VE[FT/SEC]	0.00	42.24	66.78	70.04	63.36	66.78	66.73
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	1.10	1.60	2.70	3.50	4.20	4.00	3.20
VE[FT/SEC]	79.04	84.47	109.74	126.71	136.86	133.57	119.46
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	2.40	2.60	3.60	4.10	4.50	4.30	3.70
VE[FT/SEC]	107.46	107.68	126.71	135.22	141.67	138.48	128.46
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	2.40	1.50	0.90	0.60	0.90	1.00	0.90
VE[FT/SEC]	103.46	81.79	63.36	59.73	63.36	66.78	63.36
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	6.70	0.50	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 02 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	2.50	3.60	4.20	4.60	5.20	5.00
VE[FT/SEC]	0.00	105.59	126.71	136.86	143.23	152.29	149.33
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	4.00	3.50	3.60	4.00	4.30	4.00	3.20
VE[FT/SEC]	133.57	124.94	126.71	133.57	138.46	133.57	119.46
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	2.30	2.40	3.30	4.00	3.90	4.10	4.30
VE[FT/SEC]	101.28	103.46	121.32	133.57	131.89	135.22	138.48
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	4.20	4.00	3.80	4.00	3.60	3.40	2.90
VE[FT/SEC]	136.86	133.57	130.18	133.57	126.71	123.14	113.73
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	2.30	0.80	0.00				

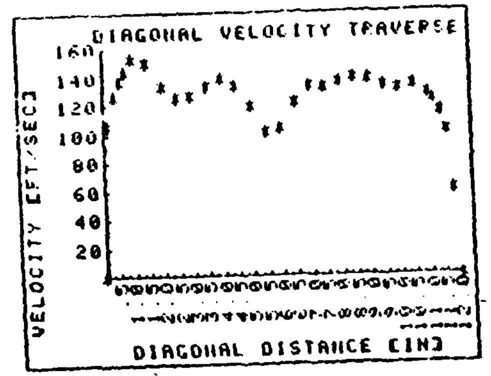


TABLE 15.3 - VTD DATA FOR 15/25 NOZZLES WITH L/D=1.75 AND S/D=0.25 STACK

DATA TAKEN ON: 11 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/30 ROTATION (MAX 35)

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.06 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	60.2	113.2	72.2	3.25	3.11	0.00	0.000	*******
2	0.70	22.0	59.2	112.0	72.4	4.15	2.20	0.00	12.566	*******
3	0.70	22.0	59.4	113.0	73.0	4.75	1.59	0.00	25.133	*******
4	0.70	22.0	59.6	113.2	73.0	5.40	0.87	0.00	50.265	*******
5	0.70	22.1	58.0	112.8	73.0	6.00	0.33	0.00	100.531	*******
6	0.70	22.1	59.2	112.0	73.0	6.15	0.19	0.00	150.796	*******
7	0.70	22.0	58.6	112.0	73.0	6.20	0.13	0.00	201.062	*******
8	0.70	22.0	59.6	113.2	73.6	6.25	0.08	0.00	245.044	*******
9	0.70	22.0	58.0	113.0	73.0	6.30	0.02	0.00	*******	*******

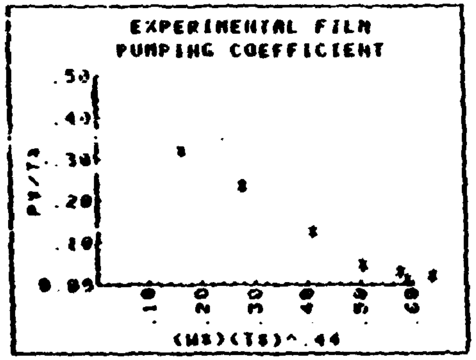
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T'.44	WP	WS	UP	UH	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4197	0.9284	0.4521	0.0000	3.7515	0.0000	181.92	72.77	72.77	0.062
2	0.1695	0.2396	0.9291	0.3223	0.1642	3.7466	0.6352	181.15	83.82	72.47	0.062
3	0.2892	0.2173	0.9302	0.2336	0.2791	3.7459	1.0794	180.90	91.69	72.37	0.062
4	0.4251	0.1186	0.9298	0.1276	0.4117	3.7452	1.5922	180.61	100.75	72.25	0.062
5	0.5236	0.0452	0.9305	0.0485	0.5073	3.7566	1.9669	180.80	107.53	72.33	0.062
6	0.5962	0.0260	0.9305	0.0280	0.5776	3.7551	2.2387	180.66	112.34	72.27	0.062
7	0.6586	0.0179	0.9305	0.0192	0.6381	3.7488	2.4691	180.33	116.33	72.14	0.062
8	0.6103	0.0103	0.9290	0.0111	0.5911	3.7452	2.2857	180.26	113.02	72.11	0.061
9	******	0.0020	0.9302	0.0030	******	3.7481	3.7011	180.31	******	72.13	0.061

TABLE 16 - PCD DATA FOR 15/30 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	MT*	PT*	TT*	PT*/TT*	MT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9294	0.0000	*******	3.751	*******	******
2	******	0.0000	0.9294	0.0000	*******	4.392	*******	******
3	******	0.0000	0.9302	0.0000	*******	4.825	*******	******
4	******	0.0000	0.9298	0.0000	*******	5.337	*******	******
5	******	0.0000	0.9305	0.0000	*******	5.724	*******	******
6	******	0.0000	0.9305	0.0000	*******	5.994	*******	******
7	******	0.0000	0.9305	0.0000	*******	6.218	*******	******
8	******	0.0000	0.9298	0.0000	*******	6.031	*******	******
9	******	0.0000	0.9302	0.0000	*******	******	*******	******



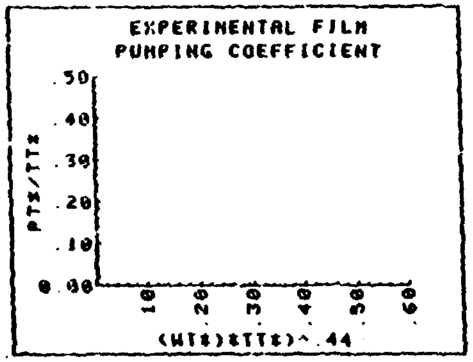


TABLE 18.1 - PCD DATA (CONT) FOR 15/30 NOZZLES WITH L/D=1.75 STACK

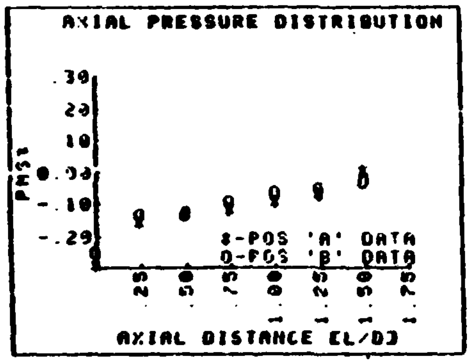
MIXING STACK DATA FOR RUN 9

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.140	96	-0.294
0.25	-1.150	18	-0.158
0.50	-0.955	14	-0.131
0.75	-0.840	24	-0.116
1.00	-0.695	18	-0.096
1.25	-0.510	22	-0.070
1.50	0.025	28	0.003

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.830	96	-0.252
0.25	-0.985	18	-0.136
0.50	-0.905	13	-0.125
0.75	-0.675	24	-0.093
1.00	-0.475	18	-0.065
1.25	-0.395	22	-0.054
1.50	-0.205	28	-0.020



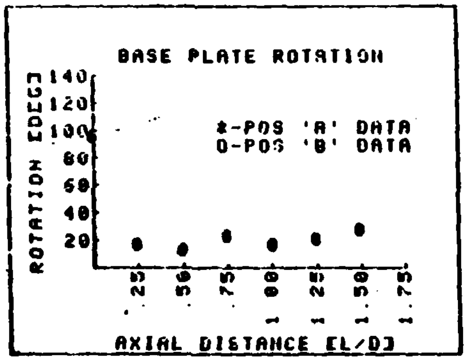
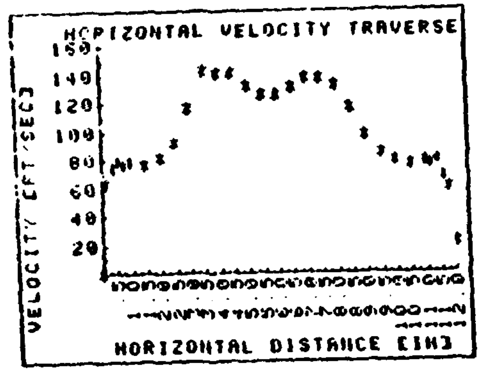


TABLE 16.2 - MSD DATA FOR 15/30 NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 76 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	0.90	1.20	1.40	1.30	1.40	1.30
V[FT/SEC]	0.00	63.45	73.26	79.13	76.26	79.13	76.26
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	1.50	1.90	3.00	4.50	4.40	4.40	3.90
V[FT/SEC]	61.91	92.19	115.84	141.88	140.29	140.29	132.08
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.50	3.50	3.80	4.20	4.20	3.90	3.00
V[FT/SEC]	125.12	125.12	130.38	137.07	137.07	132.08	115.34
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	2.10	1.60	1.40	1.30	1.40	1.30	1.40
V[FT/SEC]	96.92	84.60	79.13	76.26	79.13	76.26	79.13
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	1.00	0.66	0.10				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 76 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]	0.00	1.00	3.30	3.60	4.10	4.50	4.80
V[FT/SEC]	0.00	66.88	121.50	130.38	135.42	141.88	146.53
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]	4.60	4.30	4.30	4.50	4.70	4.50	3.80
V[FT/SEC]	143.44	139.69	139.69	141.88	144.99	141.88	130.38
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]	3.69	3.70	3.90	4.10	4.30	4.40	4.20
V[FT/SEC]	126.90	126.65	132.08	135.42	138.69	140.29	137.07
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]	4.00	4.10	4.30	4.40	4.10	3.80	3.50
V[FT/SEC]	133.76	135.42	138.69	140.29	135.42	130.38	125.12
POSIT[IN]	11.60	11.80	12.00				
P[IN H2O]	2.90	0.90	0.00				

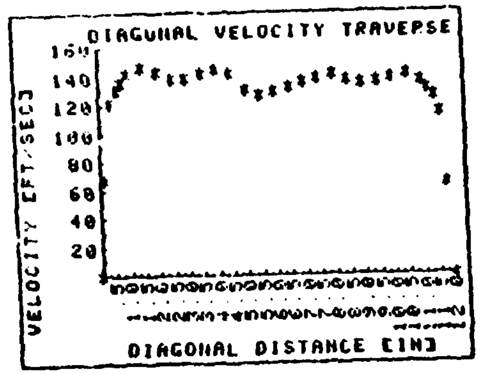


TABLE 16.3 - VTD DATA FOR 15/30 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 17 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AN/AP AREA RATIO: 2.56

COMMENTS:
20 TILT/10 ROTATION/0.5 S/D

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.96 [INHG]

N	FGP	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	55.0	109.2	67.4	3.70	3.92	0.00	0.000	*******
2	0.70	22.1	55.4	109.0	67.4	4.55	2.07	0.00	12.566	*******
3	0.70	22.0	55.2	109.0	67.4	5.05	1.48	0.00	25.133	*******
4	0.70	21.9	55.4	109.0	67.4	5.65	0.81	0.00	50.265	*******
5	0.70	22.1	55.6	109.2	67.4	6.25	0.32	0.00	100.531	*******
6	0.70	22.2	55.6	109.2	67.6	6.40	0.10	0.00	150.796	*******
7	0.70	22.1	54.8	109.0	68.0	6.50	0.02	0.00	*******	*******

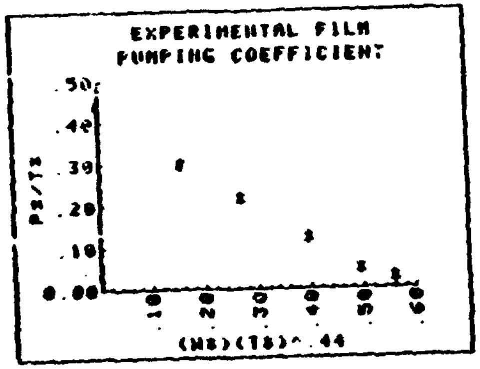
SECONDARY BOX

N	H*	P*	T*	PA/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4057	0.9265	0.4378	0.0000	3.7641	0.0000	161.82	72.73	72.74	0.062
2	0.1642	0.2726	0.9268	0.3919	0.1588	3.7627	0.6130	181.26	83.49	72.51	0.062
3	0.2783	0.2015	0.9268	0.2174	0.2692	3.7549	1.0452	180.62	90.83	72.26	0.062
4	0.4120	0.1112	0.9268	0.1199	0.3993	3.7456	1.5464	179.88	99.44	71.96	0.062
5	0.5127	0.0429	0.9265	0.0463	0.4958	3.7620	1.9287	180.51	106.48	72.21	0.062
6	0.5799	0.0244	0.9269	0.0264	0.5608	3.7704	2.1865	180.86	111.22	72.35	0.062
7	******	0.0027	0.9279	0.0029	******	3.7649	3.7927	180.46	******	72.19	0.062

TABLE 17 - PCD DATA FOR 20/10 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9265	0.0000	*******	3.764	*******	******
2	******	0.0000	0.9268	0.0000	*******	4.381	*******	******
3	******	0.0000	0.9268	0.0000	*******	4.800	*******	******
4	******	0.0000	0.9268	0.0000	*******	5.292	*******	******
5	******	0.0000	0.9265	0.0000	*******	5.691	*******	******
6	******	0.0000	0.9269	0.0000	*******	5.957	*******	******
7	******	0.0000	0.9279	0.0000	*******	******	*******	******



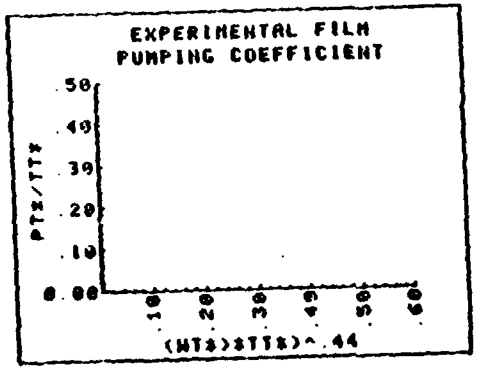


TABLE 17.1 - PCD DATA (CONT) FOR 20/10 NOZZLES WITH L/D=1.75 STACK

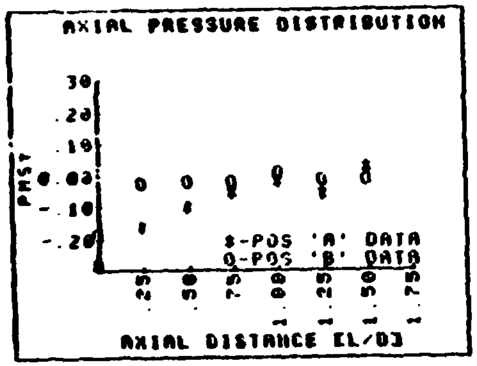
MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHST
0.00	-2.059	96	-0.290
0.25	-1.180	24	-0.161
0.50	-0.740	22	-0.101
0.75	-0.405	18	-0.055
1.00	-0.140	13	-0.019
1.25	-0.410	46	-0.056
1.50	0.180	18	0.025

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PHS*
0.00	-1.379	96	-0.187
0.25	-0.165	24	-0.023
0.50	-0.135	22	-0.018
0.75	-0.120	18	-0.016
1.00	0.060	13	0.008
1.25	-0.090	46	-0.012
1.50	-0.080	18	-0.011



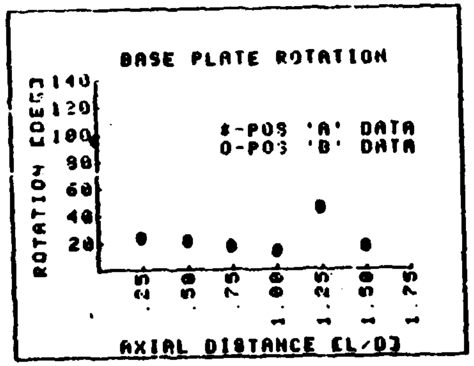
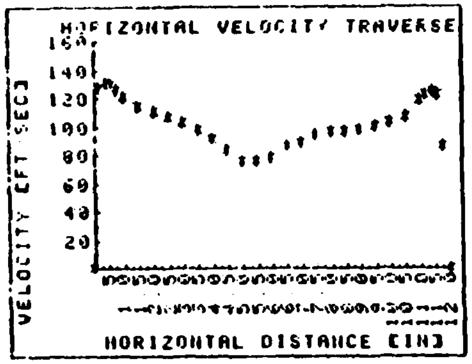


TABLE 17.2 - MSD DATA FOR 20/10 NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 05 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	3.70	3.30	3.80	3.60	3.30	3.00
VEFT/SEC]	0.00	128.26	131.68	129.93	126.51	121.13	115.49
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	2.90	2.60	2.40	2.20	1.90	1.60	1.30
VEFT/SEC]	111.57	107.51	103.30	98.90	91.91	84.34	76.02
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	1.30	1.40	1.70	1.80	2.00	2.10	2.10
VEFT/SEC]	76.02	78.89	86.94	89.46	94.30	96.62	96.62
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	2.20	2.30	2.40	2.60	3.20	3.40	3.50
VEFT/SEC]	98.90	101.12	103.30	107.51	119.20	122.95	124.74
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	3.40	1.70	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 05 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	1.20	4.40	4.70	4.70	4.40	3.70
VEFT/SEC]	0.00	73.04	139.86	144.55	144.55	139.86	128.26
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	3.10	2.70	2.40	2.20	1.90	1.60	1.30
VEFT/SEC]	117.40	109.56	103.30	98.90	91.91	84.34	76.02
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	1.30	1.50	1.80	1.90	2.10	2.20	2.20
VEFT/SEC]	76.02	81.66	89.46	91.91	96.62	98.90	98.90
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	2.40	2.60	3.10	3.70	4.10	4.30	4.40
VEFT/SEC]	103.30	107.51	117.40	128.26	135.01	138.27	139.86
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	4.10	2.80	0.00				

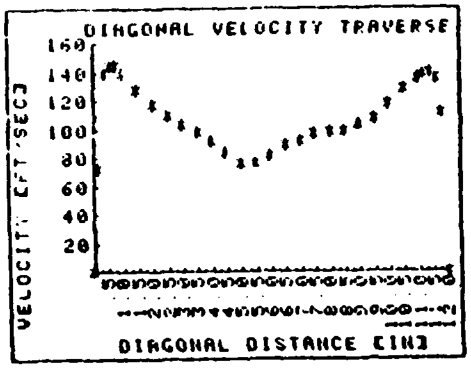


TABLE 17.3 - VTD DATA FOR 20/10 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 10 AUG 81
DATA TAKEN BY: DAVIS/DRUCKER

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/20 ROTATION/0.5 S/D

MIXING STACK INFORMATION:
LENGTH: 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.05 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	58.6	112.2	71.0	3.50	2.99	0.00	0.000	*******
2	0.70	22.0	58.6	112.2	72.0	4.30	2.13	0.00	12.566	*******
3	0.69	21.0	59.2	112.6	72.2	4.90	1.51	0.00	25.133	*******
4	0.70	22.0	58.0	112.6	72.2	5.60	0.87	0.00	50.265	*******
5	0.70	22.0	59.2	112.6	72.2	6.10	0.33	0.00	100.531	*******
6	0.70	22.0	59.2	112.6	72.2	6.20	0.19	0.00	150.796	*******
7	0.70	22.0	50.0	112.6	72.4	6.35	0.01	0.00	*******	*******

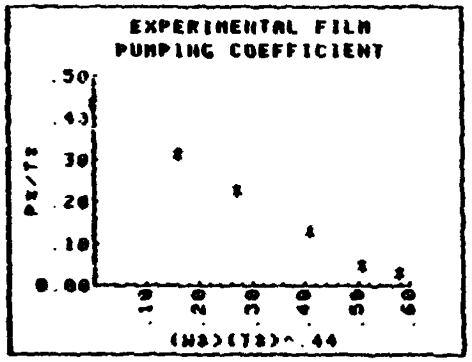
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4055	0.9294	0.4363	0.0000	3.7481	0.0000	181.44	72.58	72.58	0.062
2	0.1668	0.2902	0.9297	0.3121	0.1615	3.7482	0.6251	181.06	83.60	72.43	0.062
3	0.2822	0.2083	0.9294	0.2241	0.2733	3.7290	1.0525	179.99	90.82	72.00	0.061
4	0.4264	0.1192	0.9294	0.1282	0.4128	3.7474	1.5978	180.59	100.81	72.24	0.062
5	0.5254	0.0454	0.9294	0.0488	0.5087	3.7460	1.9681	180.28	107.30	72.12	0.062
6	0.5980	0.0261	0.9294	0.0281	0.5790	3.7460	2.2400	180.22	112.14	72.10	0.061
7	******	0.0014	0.9290	0.0015	******	3.7475	2.6747	180.21	******	72.09	0.061

TABLE 18 - PCD DATA FOR 20/20 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	######	0.0000	0.9294	0.0000	#######	3.748	#######	######
2	######	0.0000	0.9297	0.0000	#######	4.373	#######	######
3	######	0.0000	0.9294	0.0000	#######	4.781	#######	######
4	######	0.0000	0.9294	0.0000	#######	5.345	#######	######
5	######	0.0000	0.9294	0.0000	#######	5.714	#######	######
6	######	0.0000	0.9294	0.0000	#######	5.986	#######	######
7	######	0.0000	0.9290	0.0000	#######	######	#######	######



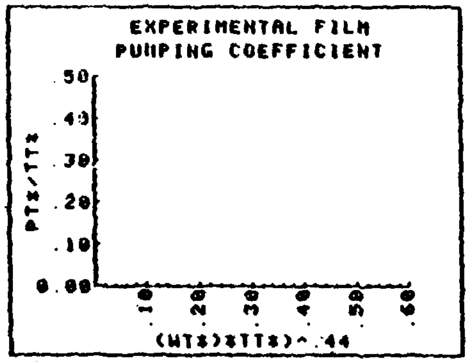


TABLE 18.1 - PCD DATA (CONT) FOR 20/20 NOZZLES WITH L/D=1.75 STACK

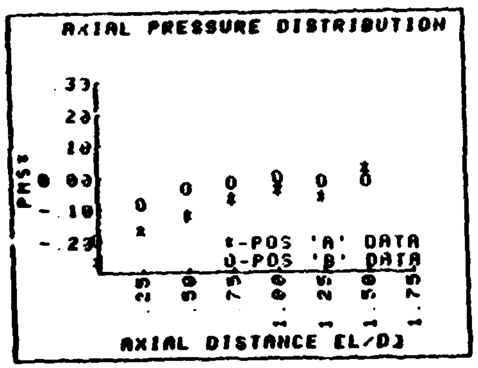
MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.935	72	-0.266
0.25	-1.205	26	-0.166
0.50	-0.695	12	-0.123
0.75	-0.525	15	-0.072
1.00	-0.320	6	-0.044
1.25	-0.465	38	-0.064
1.50	0.185	6	0.025

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.410	72	-0.194
0.25	-0.605	26	-0.083
0.50	-0.265	12	-0.036
0.75	-0.145	15	-0.020
1.00	-0.030	6	-0.004
1.25	-0.105	38	-0.014
1.50	-0.075	6	-0.010



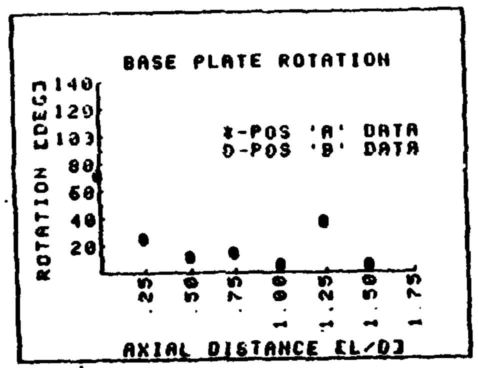
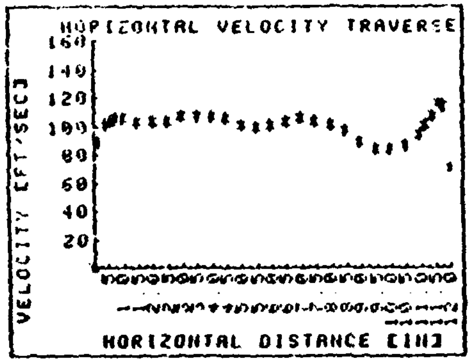


TABLE 18.2 - MSD DATA FOR 20/20 NOZZLES WITH L/D=1.75 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 72 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	1.30	2.30	2.40	2.50	2.50	2.40
VE[FT/SEC]	0.00	89.69	101.39	103.57	105.71	105.71	103.57
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	2.40	2.40	2.60	2.60	2.60	2.50	2.30
VE[FT/SEC]	103.57	103.57	107.80	107.80	107.80	105.71	101.39
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	2.20	2.30	2.40	2.50	2.40	2.30	2.10
VE[FT/SEC]	99.16	101.39	103.57	105.71	103.57	101.39	96.88
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	1.80	1.60	1.60	1.70	2.00	2.30	2.60
VE[FT/SEC]	89.69	84.56	84.56	87.17	94.55	101.39	107.80
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	3.00	2.90	1.10				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 72 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.30	4.20	4.50	4.50	4.20	3.50
VE[FT/SEC]	0.00	36.62	137.01	141.82	141.82	137.01	125.07
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	3.00	2.70	2.60	2.70	2.50	2.30	2.20
VE[FT/SEC]	115.30	109.85	107.80	109.85	105.71	101.39	99.16
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	2.20	2.30	2.50	2.40	2.30	2.10	2.10
VE[FT/SEC]	99.16	101.39	105.71	103.57	101.39	96.88	96.88
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	2.20	2.30	2.70	3.30	4.00	4.20	4.20
VE[FT/SEC]	99.16	101.39	109.85	121.45	133.71	137.01	137.01
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	4.00	2.60	0.00				

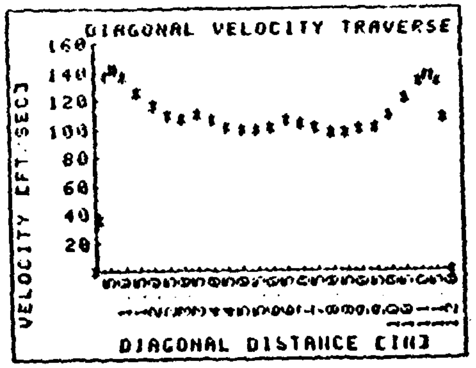


TABLE 18.3 - VTD DATA FOR 20/20 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/30 ROTATION [MAX]/PCD

MIXING STACK INFORMATION:
LENGTH: 20.48 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.11 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.0	61.0	113.6	70.4	3.40	3.05	0.00	0.000	*******
2	0.70	22.0	60.0	113.0	70.4	4.30	2.19	0.00	12.566	*******
3	0.70	22.0	60.4	113.6	70.6	4.90	1.57	0.00	25.133	*******
4	0.70	22.0	60.0	113.0	70.6	5.55	0.86	0.00	50.265	*******
5	0.70	22.0	60.6	113.0	70.0	6.10	0.34	0.00	100.531	*******
6	0.70	21.9	61.0	114.0	71.2	6.20	0.20	0.00	150.796	*******
7	0.69	21.9	61.0	114.0	71.4	6.35	0.01	0.00	*******	*******

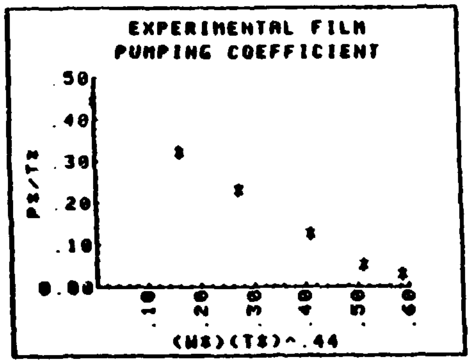
SECONDARY BOX

N	WS	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4123	0.9246	0.4459	0.0000	3.7433	0.0000	181.31	72.53	72.53	0.062
2	0.1697	0.2970	0.9243	0.3213	0.1639	3.7440	0.6354	181.03	83.72	72.42	0.062
3	0.2873	0.2136	0.9250	0.2309	0.2776	3.7454	1.0759	180.76	91.45	72.31	0.062
4	0.4254	0.1174	0.9247	0.1270	0.4110	3.7440	1.5925	180.44	100.51	72.10	0.061
5	0.5300	0.0459	0.9250	0.0496	0.5129	3.7447	1.9875	180.24	107.47	72.10	0.061
6	0.6080	0.0269	0.9254	0.0290	0.5884	3.7340	2.2737	179.76	112.40	71.91	0.061
7	******	0.0014	0.9257	0.0015	******	3.7340	2.6799	179.60	******	71.80	0.061

TABLE 10 - PCD DATA FOR 20/30 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9246	0.0000	*******	3.743	*******	******
2	******	0.0000	0.9243	0.0000	*******	4.379	*******	******
3	******	0.0000	0.9250	0.0000	*******	4.821	*******	******
4	******	0.0000	0.9247	0.0000	*******	5.337	*******	******
5	******	0.0000	0.9250	0.0000	*******	5.732	*******	******
6	******	0.0000	0.9254	0.0000	*******	6.008	*******	******
7	******	0.0000	0.9257	0.0000	*******	******	*******	******



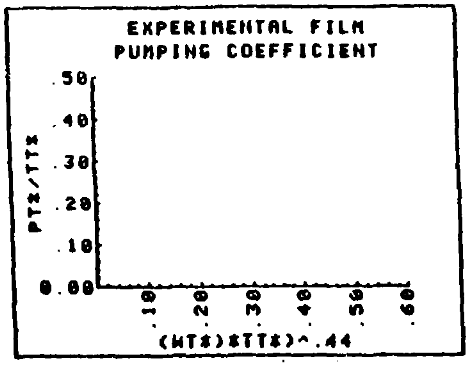


TABLE 10.1 - PCD DATA (CONT) FOR 20/30 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 22.5 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.12 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	60.2	113.4	70.8	4.10	2.95	0.00	0.000	*******
2	0.70	22.0	60.0	113.6	70.0	4.75	2.01	0.00	12.566	*******
3	0.70	22.1	60.6	113.0	70.8	5.35	1.44	0.00	25.133	*******
4	0.70	21.9	60.4	114.0	71.2	5.95	0.78	0.60	50.265	*******
5	0.70	22.2	60.2	113.0	71.4	6.45	0.30	0.00	100.531	*******
6	0.70	22.1	60.4	113.8	71.2	6.60	0.17	0.00	150.796	*******
7	0.70	22.1	61.0	114.0	71.4	6.70	0.01	0.00	*******	*******

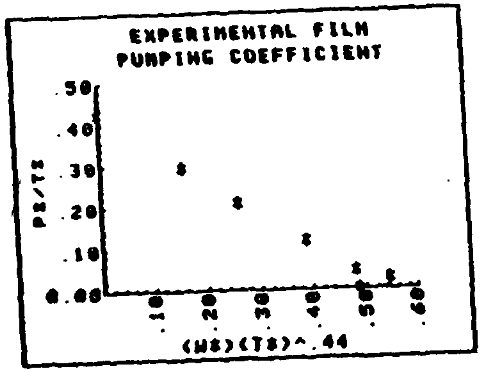
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3965	0.9257	0.4283	0.0000	3.7553	0.0000	181.72	72.69	72.70	0.062
2	0.1625	0.2732	0.9253	0.2952	0.1571	3.7446	0.6086	180.86	83.17	72.35	0.062
3	0.2740	0.1945	0.9250	0.2103	0.2640	3.7538	1.0286	181.11	90.75	72.45	0.062
4	0.4056	0.1070	0.9254	0.1156	0.3920	3.7375	1.5161	190.10	99.03	72.04	0.061
5	0.4995	0.0407	0.9261	0.0440	0.4829	3.7630	1.8801	181.08	105.92	72.44	0.062
6	0.5655	0.0232	0.9257	0.0251	0.5466	3.7546	2.1233	180.50	110.04	72.24	0.062
7	******	0.0007	0.9257	0.0007	******	3.7524	1.0953	180.47	******	72.19	0.061

TABLE 20 - PCD DATA FOR 22.5/10 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
						LBM/SEC	LBM/SEC	FT/SEC
RUN								
1	******	0.0000	0.9257	0.0000	*******	3.755	*******	******
2	******	0.0000	0.9253	0.0000	*******	4.353	*******	******
3	******	0.0000	0.9250	0.0000	*******	4.782	*******	******
4	******	0.0000	0.9254	0.0000	*******	5.254	*******	******
5	******	0.0000	0.9261	0.0000	*******	5.644	*******	******
6	******	0.0000	0.9257	0.0000	*******	5.878	*******	******
7	******	0.0000	0.9257	0.0000	*******	******	*******	******



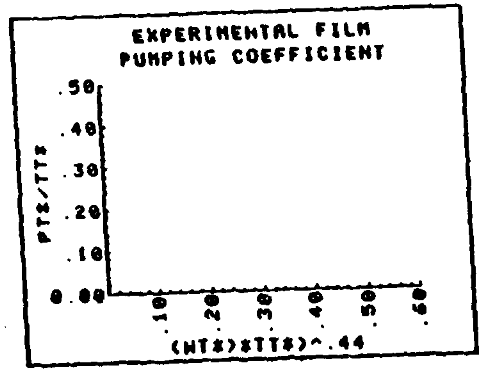


TABLE 20.1 - PCD DATA (CONT) FOR 22.5/10 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 20.40 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.75
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 22.5 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.13 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.69	22.1	60.2	113.4	71.0	3.70	2.96	0.00	0.000	*******
2	0.69	22.0	60.2	113.8	71.6	4.55	2.13	0.00	12.566	*******
3	0.69	22.0	60.2	113.0	71.6	5.10	1.51	0.00	25.133	*******
4	0.69	22.0	60.2	113.0	71.0	5.80	0.83	0.00	50.265	*******
5	0.70	22.1	60.2	113.0	71.0	6.35	0.31	0.00	100.531	*******
6	0.69	22.1	60.2	113.0	71.0	6.45	0.16	0.00	150.796	*******
7	0.70	22.0	60.4	114.0	72.0	6.60	0.01	0.00	*******	*******

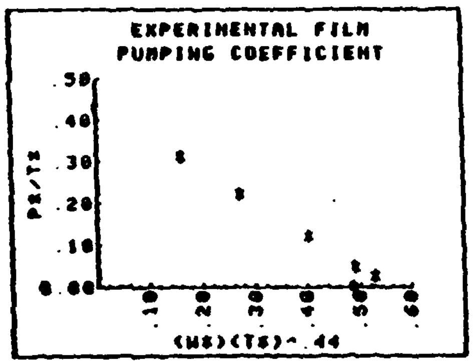
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3992	0.9274	0.4304	0.0000	3.7556	0.0000	181.72	72.69	72.69	0.062
2	0.1671	0.2892	0.9264	0.3122	0.1616	3.7471	0.6261	181.06	83.58	72.43	0.062
3	0.2814	0.2057	0.9264	0.2220	0.2721	3.7471	1.0544	180.79	91.10	72.32	0.062
4	0.4172	0.1135	0.9260	0.1224	0.4034	3.7471	1.5631	180.49	100.06	72.20	0.062
5	0.5087	0.0423	0.9260	0.0456	0.4920	3.7556	1.9106	180.66	106.32	72.27	0.062
6	0.5482	0.0210	0.9260	0.0236	0.5302	3.7556	2.0589	180.60	108.94	72.25	0.062
7	******	0.0007	0.9260	0.0007	******	3.7464	1.0944	180.15	******	72.07	0.061

TABLE 21 - PCD DATA FOR 22.5/20 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

M RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9274	0.0000	*******	3.756	*******	******
2	******	0.0000	0.9264	0.0000	*******	4.373	*******	******
3	******	0.0000	0.9264	0.0000	*******	4.802	*******	******
4	******	0.0000	0.9260	0.0000	*******	5.310	*******	******
5	******	0.0000	0.9260	0.0000	*******	5.666	*******	******
6	******	0.0000	0.9260	0.0000	*******	5.815	*******	******
7	******	0.0000	0.9260	0.0000	*******	******	*******	******



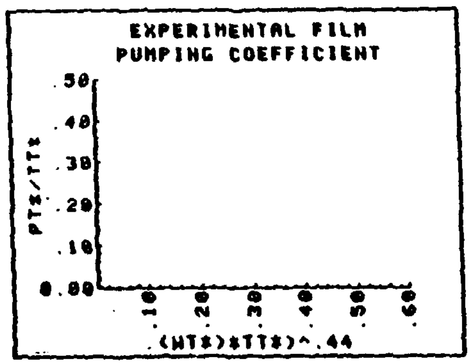


TABLE 21.1 - PCD DATA (CONT) FOR 22.5/20 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 19 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/25 ROTATION/PCD

MIXING STACK INFORMATION:
- LENGTH: 20.40 [IN]
- DIAMETER: 11.70 [IN]
- L/D RATIO: 1.75
- S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
- TILT ANGLE: 22.5 [DEG]
- ROTATION ANGLE: 25 [DEG]
- AREA PER NOZZLE: 10.752 [IN2]
- NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
- ORIFICE DIAMETER: 6.902 [IN]
- ORIFICE BETA: 0.497
- UPTAKE AREA: 107.510 [IN2]
- ATM PRESSURE: 30.13 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	59.4	113.2	71.0	3.55	3.12	0.00	0.000	*******
2	0.70	21.9	59.4	113.2	72.0	4.45	2.20	0.00	12.566	*******
3	0.70	22.1	59.2	113.0	72.0	5.05	1.50	0.00	25.133	*******
4	0.69	22.0	58.0	112.0	72.0	5.75	0.86	0.00	50.265	*******
5	0.69	21.9	59.2	112.8	72.0	6.20	0.34	0.00	100.531	*******
6	0.69	22.0	59.6	113.0	72.0	6.40	0.19	0.00	150.796	*******
7	0.70	22.0	59.2	113.0	72.2	6.55	0.01	0.00	*******	*******

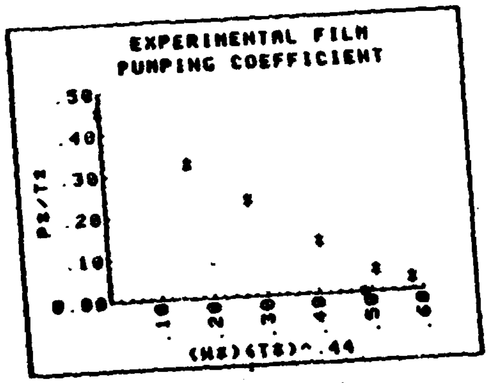
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4201	0.9277	0.4528	0.0000	3.7585	0.0000	101.86	72.75	72.75	0.062
2	0.1690	0.2937	0.9281	0.3229	0.1643	3.7415	0.6354	100.63	83.58	72.26	0.062
3	0.2864	0.2130	0.9294	0.2303	0.2771	3.7592	1.0765	101.15	91.65	72.47	0.062
4	0.4237	0.1175	0.9287	0.1265	0.4101	3.7551	1.5908	100.57	100.59	72.23	0.062
5	0.5307	0.0462	0.9287	0.0498	0.5137	3.7422	1.9858	179.72	107.29	71.89	0.061
6	0.5983	0.0261	0.9284	0.0281	0.5791	3.7493	2.2433	100.06	112.02	72.03	0.061
7	******	0.0007	0.9288	0.0007	******	3.7587	1.0940	100.04	******	72.02	0.061

TABLE 22 - PCD DATA FOR 22.5/25 NOZZLES WITH L/D=1.75 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
						LBM/SEC	LBM/SEC	FT/SEC
RUN								
1	######	0.0000	0.9277	0.0000	#######	3.758	#######	######
2	######	0.0000	0.9281	0.0000	#######	4.377	#######	######
3	######	0.0000	0.9284	0.0000	#######	4.836	#######	######
4	######	0.0000	0.9287	0.0000	#######	5.346	#######	######
5	######	0.0000	0.9287	0.0000	#######	5.728	#######	######
6	######	0.0000	0.9284	0.0000	#######	5.993	#######	######
7	######	0.0000	0.9288	0.0000	#######	######	#######	######



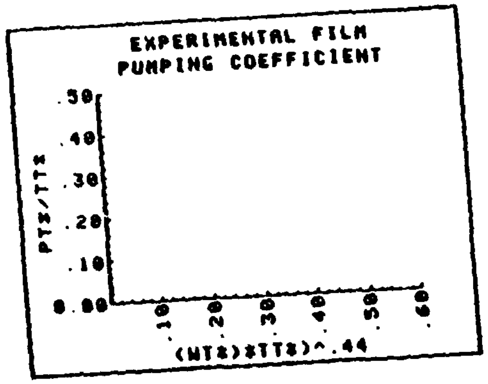


TABLE 22.1 - PCD DATA (CONT) FOR 22.5/25 NOZZLES WITH L/D=1.75 STACK

DATA TAKEN ON: 20 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
STRAIGHT NOZZLES CAL L/D=1.5

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 0.0 [DEG]
ROTATION ANGLE: 0 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.06 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	57.6	110.4	66.0	3.25	3.25	0.00	0.000	*******
2	0.70	21.9	57.0	110.6	66.0	4.20	2.14	0.00	12.566	*******
3	0.70	22.1	57.4	110.6	66.6	4.85	1.49	0.00	25.133	*******
4	0.70	22.0	57.6	110.6	66.6	5.50	0.70	0.00	50.265	*******
5	0.70	21.9	58.0	110.0	66.0	5.95	0.27	0.00	100.531	*******
6	0.70	21.9	57.6	110.0	66.0	6.05	0.15	0.00	150.796	*******
7	0.70	22.1	57.0	111.0	67.0	6.20	0.01	0.00	*******	*******

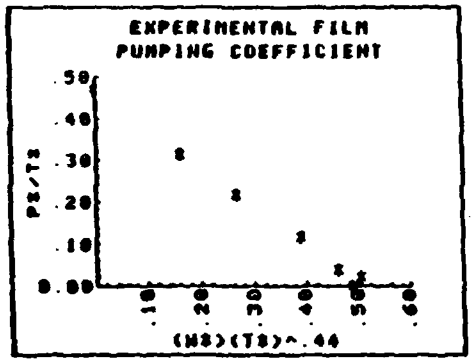
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4353	0.9221	0.4721	0.0000	3.7609	0.0000	181.54	72.62	72.62	0.062
2	0.1694	0.2907	0.9218	0.3154	0.1624	3.7432	0.6302	180.26	83.24	72.11	0.062
3	0.2790	0.2006	0.9228	0.2174	0.2693	3.7617	1.0495	180.86	90.91	72.35	0.062
4	0.4054	0.1063	0.9228	0.1152	0.3913	3.7524	1.5212	180.10	98.95	72.05	0.062
5	0.4782	0.0371	0.9229	0.0402	0.4616	3.7425	1.7896	179.46	103.45	71.79	0.061
6	0.5254	0.0199	0.9229	0.0216	0.5072	3.7439	1.9672	179.48	106.60	71.80	0.061
7	******	0.0007	0.9229	0.0007	******	3.7602	1.9013	180.26	******	72.11	0.062

TABLE 23 - PCD DATA FOR STRAIGHT NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^ 44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9221	0.0000	*******	3 761	*******	******
2	******	0.0000	0.9210	0.0000	*******	4.373	*******	******
3	******	0.0000	0.9220	0.0000	*******	4.811	*******	******
4	******	0.0000	0.9220	0.0000	*******	5.274	*******	******
5	******	0.0000	0.9229	0.0000	*******	5.532	*******	******
6	******	0.0000	0.9229	0.0000	*******	5.711	*******	******
7	******	0.0000	0.9229	0.0000	*******	******	*******	******



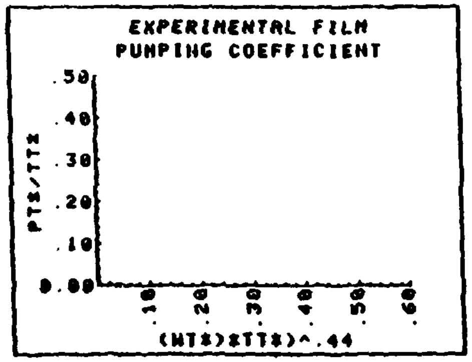


TABLE 23.1 - PCD DATA (CONT) FOR STRAIGHT NOZZLES WITH L/D=1.5 STACK

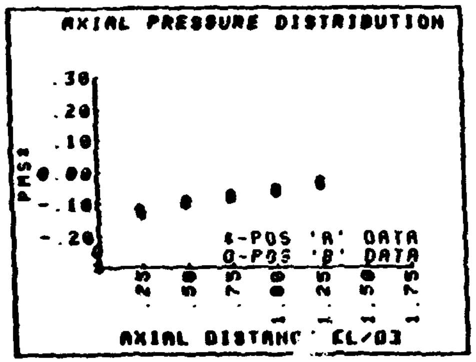
MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.100	45	-0.297
0.25	-0.965	45	-0.131
0.50	-0.735	45	-0.100
0.75	-0.595	45	-0.081
1.00	-0.385	45	-0.052
1.25	-0.240	45	-0.033

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.010	45	-0.246
0.25	-0.890	45	-0.121
0.50	-0.695	45	-0.095
0.75	-0.575	45	-0.070
1.00	-0.435	45	-0.059
1.25	-0.255	45	-0.035



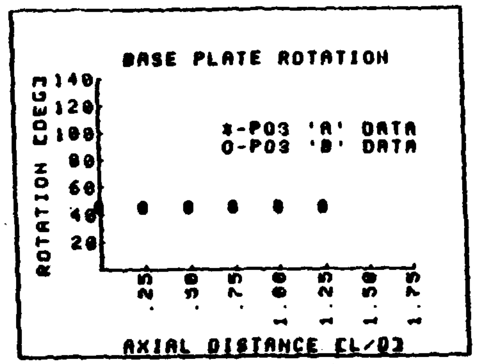
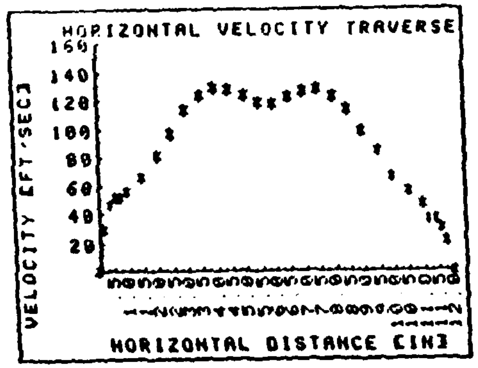


TABLE 23.2 - MSD DATA FOR STRAIGHT NOZZLES WITH L/D=1.5 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 00 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]:	0.00	0.20	0.50	0.60	0.60	0.70	1.00
VE[FT/SEC]:	0.00	29.74	47.02	51.51	51.51	55.64	66.50
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]:	1.50	2.10	2.90	3.50	3.80	3.70	3.50
VE[FT/SEC]:	81.45	96.37	113.25	124.42	129.64	127.92	124.42
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]:	3.20	3.10	3.40	3.60	3.70	3.40	2.90
VE[FT/SEC]:	118.96	117.09	122.63	126.18	127.92	122.63	113.25
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]:	2.20	1.60	1.00	0.70	0.50	0.30	0.30
VE[FT/SEC]:	98.64	84.12	66.50	55.64	47.02	36.43	36.43
POSIT[IN]:	11.60	11.80	12.00				
PE[IN H2O]:	0.20	0.10	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 00 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]:	0.00	0.90	1.50	1.80	2.00	2.30	3.60
VE[FT/SEC]:	0.00	63.09	81.45	89.22	94.05	100.86	126.18
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]:	4.90	5.80	5.80	5.20	4.50	4.00	3.50
VE[FT/SEC]:	147.21	160.16	160.16	151.65	141.07	133.01	124.42
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]:	3.20	3.10	3.40	4.00	4.70	5.40	5.90
VE[FT/SEC]:	118.96	117.09	122.63	133.01	144.18	154.54	161.54
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]:	6.10	5.90	4.90	3.40	2.30	2.00	1.80
VE[FT/SEC]:	164.25	161.54	147.21	122.63	100.86	94.05	89.22
POSIT[IN]:	11.60	11.80	12.00				
PE[IN H2O]:	1.50	0.90	0.00				

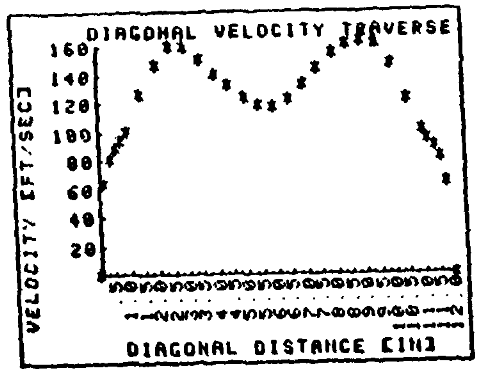


TABLE 23.3 - VTD DATA FOR STRAIGHT NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/10 ROTATION/PCD ONLY

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.02 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	60.2	112.2	69.4	3.20	3.10	0.00	0.000	*******
2	0.70	22.0	60.0	112.4	69.6	4.10	2.21	0.00	12.566	*******
3	0.70	21.9	60.2	112.6	69.6	4.65	1.56	0.00	25.133	*******
4	0.70	22.1	60.4	112.6	69.6	5.40	0.84	0.00	50.265	*******
5	0.70	22.0	60.4	113.0	69.8	5.90	0.31	0.00	100.531	*******
6	0.70	22.0	60.4	113.2	70.0	6.05	0.16	0.00	150.796	*******
7	0.70	22.0	60.6	113.4	70.2	6.20	0.01	0.00	*******	*******

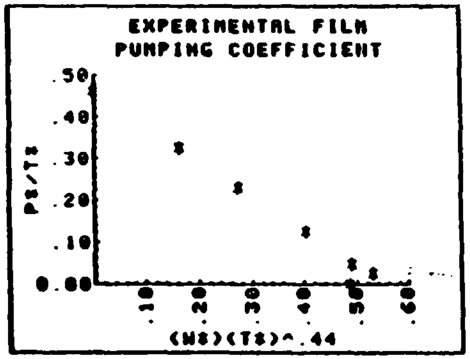
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4263	0.9252	0.4608	0.0000	3.7575	0.0000	102.16	72.87	72.87	0.062
2	0.1705	0.3002	0.9252	0.3245	0.1640	3.7412	0.6379	101.01	83.77	72.41	0.062
3	0.2072	0.2135	0.9249	0.2308	0.2775	3.7320	1.0719	100.34	91.23	72.14	0.062
4	0.4197	0.1144	0.9249	0.1237	0.4055	3.7403	1.5730	100.00	100.34	72.33	0.062
5	0.5110	0.0425	0.9246	0.0459	0.4936	3.7398	1.9109	100.20	106.16	72.12	0.061
6	0.5505	0.0219	0.9246	0.0237	0.5319	3.7390	2.0508	100.20	100.01	72.12	0.061
7	******	0.0007	0.9246	0.0007	******	3.7391	1.0943	100.24	******	72.10	0.061

TABLE 24 - PCD DATA FOR 10/10 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9252	0.0000	*******	3.757	*******	******
2	******	0.0000	0.9252	0.0000	*******	4.379	*******	******
3	******	0.0000	0.9249	0.0000	*******	4.804	*******	******
4	******	0.0000	0.9249	0.0000	*******	5.321	*******	******
5	******	0.0000	0.9246	0.0000	*******	5.651	*******	******
6	******	0.0000	0.9246	0.0000	*******	5.799	*******	******
7	******	0.0000	0.9246	0.0000	*******	******	*******	******



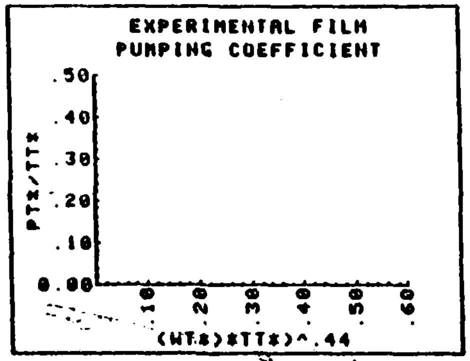


TABLE 24.1 - PCD DATA (CONT) FOR 10/10 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	60.0	113.6	70.2	3.25	3.15	0.00	0.000	*******
2	0.70	21.9	60.2	113.6	70.2	4.15	2.13	0.00	12.566	*******
3	0.70	22.1	60.0	113.4	70.2	4.85	1.51	0.00	25.133	*******
4	0.70	22.0	60.2	113.4	70.4	5.45	0.79	0.00	50.265	*******
5	0.70	21.9	60.0	113.8	70.6	5.90	0.27	0.00	100.531	*******
6	0.70	21.9	61.0	113.8	70.6	6.05	0.14	0.00	150.796	*******
7	0.71	22.1	60.0	114.0	70.0	6.25	0.01	0.00	*******	*******

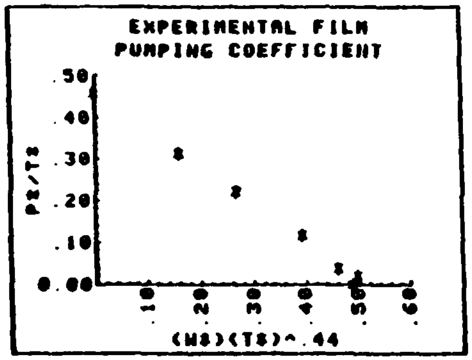
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4233	0.9243	0.4580	0.0000	3.7475	0.0000	182.05	72.82	72.83	0.062
2	0.1677	0.2900	0.9243	0.3137	0.1620	3.7326	0.6260	180.87	83.51	72.36	0.062
3	0.2811	0.2044	0.9246	0.2211	0.2715	3.7504	1.0541	181.39	91.35	72.56	0.062
4	0.4075	0.1079	0.9250	0.1166	0.3930	3.7412	1.5246	180.63	99.44	72.26	0.062
5	0.4770	0.0371	0.9247	0.0402	0.4616	3.7305	1.7823	180.01	103.80	72.01	0.061
6	0.5161	0.0193	0.9247	0.0208	0.4987	3.7298	1.9251	179.92	106.31	71.97	0.061
7	******	0.0007	0.9247	0.0007	******	3.7475	1.0935	180.77	******	72.32	0.062

TABLE 25 - PCD DATA FOR 10/20 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9243	0.0000	*******	3.747	*******	******
2	******	0.0000	0.9243	0.0000	*******	4.359	*******	******
3	******	0.0000	0.9246	0.0000	*******	4.805	*******	******
4	******	0.0000	0.9250	0.0000	*******	5.266	*******	******
5	******	0.0000	0.9247	0.0000	*******	5.513	*******	******
6	******	0.0000	0.9247	0.0000	*******	5.655	*******	******
7	******	0.0000	0.9247	0.0000	*******	******	*******	******



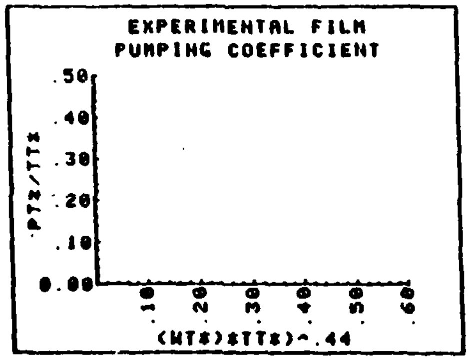


TABLE 25.1 - PCD DATA (CONT) FOR 10/20 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:		PRIMARY NOZZLE INFORMATION:		MISCELLANEOUS INFORMATION:	
LENGTH:	17.55 [IN]	TILT ANGLE:	10.0 [DEG]	ORIFICE DIAMETER:	6.902 [IN]
DIAMETER:	11.70 [IN]	ROTATION ANGLE:	30 [DEG]	ORIFICE BETA:	0.497
L/D RATIO:	1.50	AREA PER NOZZLE:	10.752 [IN2]	UPTAKE AREA:	107.510 [IN2]
S/D RATIO:	0.50	NUMBER OF NOZZLES:	4	ATM. PRESSURE:	30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.72	22.3	60.4	113.6	70.0	3.45	3.04	0.00	0.000	*******
2	0.71	22.2	60.4	113.6	70.0	4.40	2.01	0.00	12.566	*******
3	0.71	22.1	60.4	113.8	71.0	4.95	1.37	0.00	25.133	*******
4	0.71	22.2	60.0	113.8	71.0	5.65	0.71	0.00	50.265	*******
5	0.71	22.1	60.4	113.8	71.0	6.05	0.25	0.00	100.531	*******
6	0.71	22.1	60.4	113.8	71.2	6.20	0.12	0.00	150.796	*******
7	0.70	22.0	60.4	113.8	71.4	6.20	0.01	0.00	*******	*******

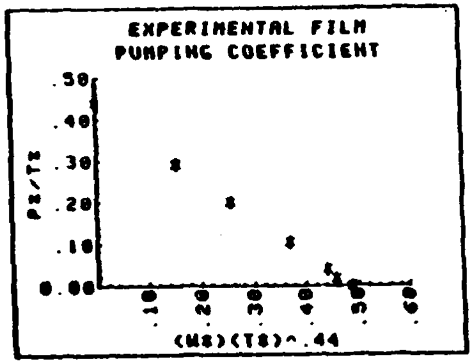
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^ 44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4053	0.9253	0.4380	0.0000	3.7658	0.0000	182.89	73.16	73.16	0.062
2	0.1519	0.2711	0.9253	0.2930	0.1565	3.7531	0.6077	181.81	83.57	72.73	0.062
3	0.2676	0.1857	0.9254	0.2007	0.2587	3.7489	1.0033	181.38	90.47	72.56	0.062
4	0.3843	0.0961	0.9254	0.1038	0.3714	3.7588	1.4445	181.57	98.42	72.63	0.062
5	0.4573	0.0341	0.9254	0.0368	0.4420	3.7489	1.7144	180.89	102.96	72.36	0.062
6	0.4751	0.0164	0.9257	0.0177	0.4593	3.7489	1.7813	180.83	104.14	72.34	0.062
7	******	0.0007	0.9261	0.0007	******	3.7404	1.8925	180.37	******	72.15	0.061

TABLE 26 - PCD DATA FOR 10/30 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9253	0.0000	*******	3.766	*******	******
2	******	0.0000	0.9253	0.0000	*******	4.361	*******	******
3	******	0.0000	0.9254	0.0000	*******	4.752	*******	******
4	******	0.0000	0.9254	0.0000	*******	5.203	*******	******
5	******	0.0000	0.9254	0.0000	*******	5.463	*******	******
6	******	0.0000	0.9257	0.0000	*******	5.530	*******	******
7	******	0.0000	0.9261	0.0000	*******	******	*******	******



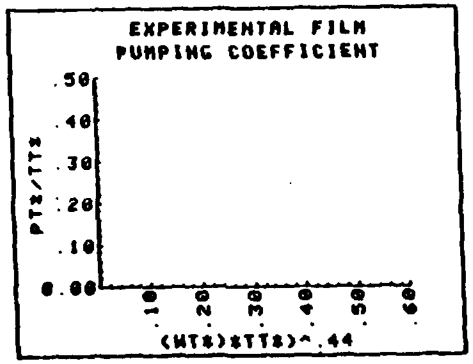


TABLE 26.1 - PCD DATA (CONT) FOR 10/30 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/40 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 40 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	60.4	113.0	71.4	3.55	2.20	0.00	0.000	*******
2	0.70	21.9	60.6	113.0	71.2	4.50	1.83	0.00	12.566	*******
3	0.71	22.2	59.8	113.6	71.4	5.15	1.25	0.00	25.133	*******
4	0.70	22.1	60.4	113.6	71.4	5.75	0.62	0.00	50.265	*******
5	0.70	22.0	60.2	113.0	71.6	6.15	0.21	0.00	100.531	*******
6	0.71	22.1	60.0	113.6	71.6	6.25	0.11	0.00	150.796	*******
7	0.71	22.1	60.2	113.6	71.8	6.35	0.01	0.00	*******	*******

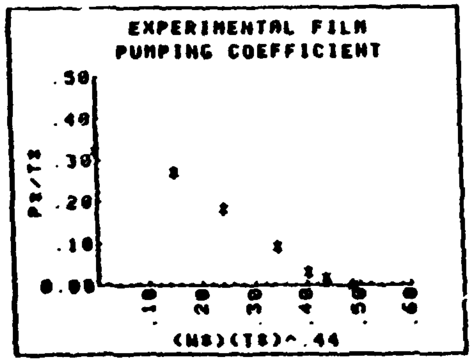
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.2986	0.9261	0.3225	0.0000	3.7404	0.0000	101.34	72.54	72.54	0.062
2	0.1554	0.2500	0.9257	0.2701	0.1502	3.7312	0.5797	100.73	82.65	72.30	0.062
3	0.2540	0.1689	0.9264	0.1823	0.2464	3.7595	0.9580	101.78	89.83	72.72	0.062
4	0.3599	0.0845	0.9264	0.0912	0.3480	3.7489	1.3494	100.99	96.50	72.40	0.062
5	0.4190	0.0288	0.9264	0.0311	0.4059	3.7412	1.5704	100.50	100.27	72.20	0.062
6	0.4546	0.0150	0.9267	0.0162	0.4396	3.7503	1.7040	100.83	102.80	72.34	0.062
7	******	0.0007	0.9271	0.0007	******	3.7496	1.8917	100.75	******	72.31	0.062

TABLE 27 - PCD DATA FOR 10/40 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9261	0.0000	*******	3.740	*******	******
2	******	0.0000	0.9257	0.0000	*******	4.311	*******	******
3	******	0.0000	0.9264	0.0000	*******	4.710	*******	******
4	******	0.0000	0.9264	0.0000	*******	5.090	*******	******
5	******	0.0000	0.9264	0.0000	*******	5.312	*******	******
6	******	0.0000	0.9267	0.0000	*******	5.455	*******	******
7	******	0.0000	0.9271	0.0000	*******	******	*******	******



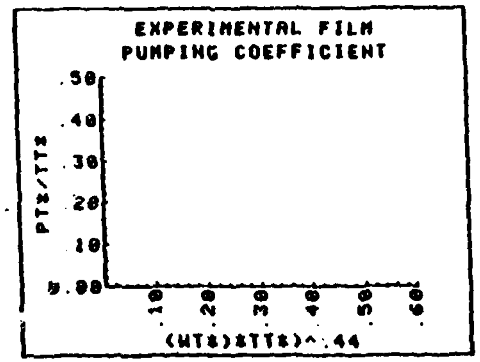


TABLE 27.1 - PCD DATA (CONT) FOR 10/40 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE MM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.2	59.6	113.4	70.4	3.45	3.07	0.00	0.000	*******
2	0.70	22.1	59.0	113.2	70.4	4.25	2.19	0.00	12.566	*******
3	0.70	21.9	60.2	113.4	70.4	4.75	1.56	0.00	25.133	*******
4	0.70	21.0	59.0	113.4	70.6	5.40	0.87	0.00	50.265	*******
5	0.70	22.1	60.0	113.4	70.0	6.00	0.33	0.00	100.531	*******
6	0.70	22.0	59.2	113.2	70.0	6.15	0.17	0.00	150.796	*******
7	0.70	22.0	60.0	113.4	71.0	6.27	0.01	0.00	*******	*******

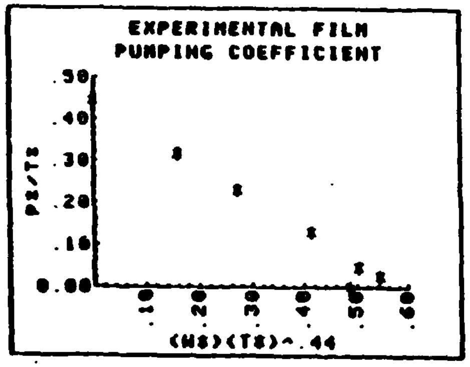
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	U*	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4104	0.9250	0.4437	0.0000	3.7603	0.0000	182.57	73.03	73.04	0.062
2	0.1692	0.2957	0.9253	0.3195	0.1635	3.7511	0.6346	181.67	83.99	72.67	0.062
3	0.2870	0.2132	0.9250	0.2305	0.2773	3.7327	1.0712	180.56	91.33	72.23	0.062
4	0.4294	0.1190	0.9253	0.1295	0.4150	3.7256	1.5996	179.91	100.50	71.97	0.061
5	0.5253	0.0450	0.9257	0.0486	0.5077	3.7504	1.9700	180.87	107.50	72.35	0.062
6	0.5664	0.0233	0.9260	0.0251	0.5475	3.7440	2.1210	180.46	110.03	72.19	0.062
7	******	0.0007	0.9260	0.0007	******	3.7419	1.0932	180.31	******	72.13	0.061

TABLE 28 - PCD DATA FOR 15/10 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9250	0.0000	*******	3.760	*******	******
2	******	0.0000	0.9253	0.0000	*******	4.386	*******	******
3	******	0.0000	0.9250	0.0000	*******	4.804	*******	******
4	******	0.0000	0.9253	0.0000	*******	5.325	*******	******
5	******	0.0000	0.9257	0.0000	*******	5.720	*******	******
6	******	0.0000	0.9260	0.0000	*******	5.866	*******	******
7	******	0.0000	0.9260	0.0000	*******	******	*******	******



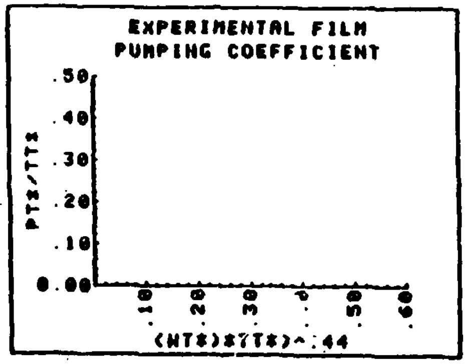


TABLE 28.1 - PCD DATA FOR 15/10 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.1	59.2	112.8	70.8	3.25	3.11	0.00	0.000	*******
2	0.70	21.9	59.4	112.0	70.8	4.10	2.21	0.00	12.566	*******
3	0.70	22.0	59.0	112.0	70.8	4.75	1.59	0.00	25.133	*******
4	0.71	22.2	59.0	112.6	70.8	5.45	0.89	0.00	50.265	*******
5	0.71	22.1	59.2	112.6	71.0	6.00	0.33	0.00	100.531	*******
6	0.71	22.1	58.8	112.4	71.2	6.15	0.17	0.00	150.796	*******
7	0.71	22.2	59.0	112.6	71.2	6.30	0.01	0.00	*******	*******

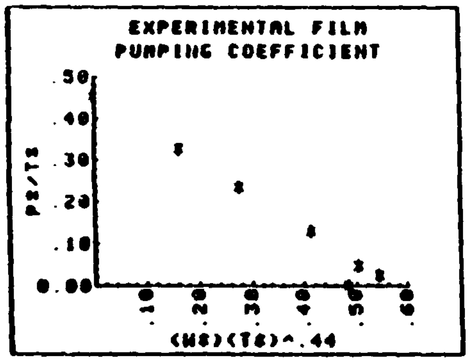
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4184	0.9266	0.4515	0.0000	3.7533	0.0000	102.06	72.83	72.83	0.062
2	0.1706	0.3015	0.9265	0.3254	0.1650	3.7355	0.6373	100.80	83.69	72.32	0.062
3	0.2086	0.2164	0.9266	0.2335	0.2791	3.7455	1.0011	101.00	91.70	72.41	0.062
4	0.4299	0.1205	0.9270	0.1300	0.4158	3.7624	1.6176	101.44	101.45	72.50	0.062
5	0.5240	0.0451	0.9273	0.0486	0.5077	3.7532	1.9697	100.75	107.46	72.31	0.062
6	0.5647	0.0232	0.9200	0.0250	0.5464	3.7547	2.1202	100.69	110.14	72.28	0.062
7	******	0.0007	0.9277	0.0007	******	3.7624	1.0920	101.05	******	72.43	0.062

TABLE 20 - PCD DATA FOR 15/20 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9266	0.0000	*******	3.753	*******	******
2	******	0.0000	0.9266	0.0000	*******	4.373	*******	******
3	******	0.0000	0.9266	0.0000	*******	4.827	*******	******
4	******	0.0000	0.9270	0.0000	*******	5.380	*******	******
5	******	0.0000	0.9273	0.0000	*******	5.723	*******	******
6	******	0.0000	0.9280	0.0000	*******	5.875	*******	******
7	******	0.0000	0.9277	0.0000	*******	******	*******	******



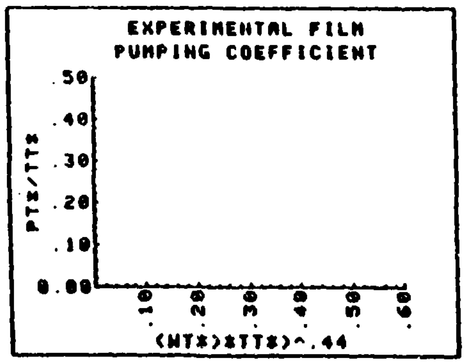


TABLE 29.1 - PCD DATA (CONT) FOR 15/20 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/20 ROTATION/FULL RUN

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.02 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	59.0	111.6	69.0	3.25	3.11	0.00	0.000	*******
2	0.70	22.1	58.0	111.6	69.0	4.15	2.23	0.00	12.566	*******
3	0.70	22.0	59.2	112.0	70.0	4.65	1.61	0.00	25.133	*******
4	0.71	22.2	59.0	112.0	70.2	5.45	0.90	0.00	50.265	*******
5	0.71	22.1	59.2	112.0	70.2	6.00	0.32	0.00	100.531	*******
6	0.71	22.1	58.0	112.0	70.4	6.15	0.17	0.00	150.796	*******
7	0.71	22.0	59.0	112.2	70.6	6.30	0.01	0.00	*******	*******

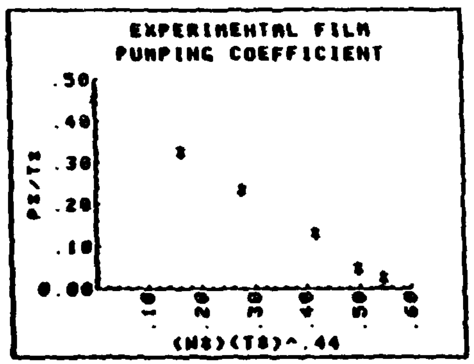
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4211	0.9268	0.4544	0.0000	3.7440	0.0000	101.33	72.54	72.54	0.062
2	0.1706	0.3018	0.9268	0.3256	0.1650	3.7541	0.6406	101.30	83.97	72.56	0.062
3	0.2987	0.2195	0.9265	0.2369	0.2811	3.7441	1.0885	100.75	91.71	72.31	0.062
4	0.4326	0.1220	0.9269	0.1316	0.4104	3.7610	1.6273	101.29	101.53	72.52	0.062
5	0.5172	0.0437	0.9269	0.0472	0.5002	3.7526	1.9407	100.59	106.84	72.24	0.062
6	0.5651	0.0232	0.9272	0.0251	0.5466	3.7541	2.1214	100.59	110.00	72.24	0.062
7	******	0.0014	0.9273	0.0015	******	3.7440	2.6779	100.14	******	72.06	0.061

TABLE 30 - PCD DATA FOR 15/20 NOZZLES WITH L/D=1.5 STACK (FULL RUN)

TERTIARY BOX

N RUN	WT$	PT$	TT$	PT$/TT$	WT$TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9268	0.0000	*******	3.745	*******	******
2	******	0.0000	0.9260	0.0000	*******	4.395	*******	******
3	******	0.0000	0.9265	0.0000	*******	4.833	*******	******
4	******	0.0000	0.9269	0.0000	*******	5.389	*******	******
5	******	0.0000	0.9269	0.0000	*******	5.693	*******	******
6	******	0.0000	0.9272	0.0000	*******	5.875	*******	******
7	******	0.0000	0.9273	0.0000	*******	******	*******	******



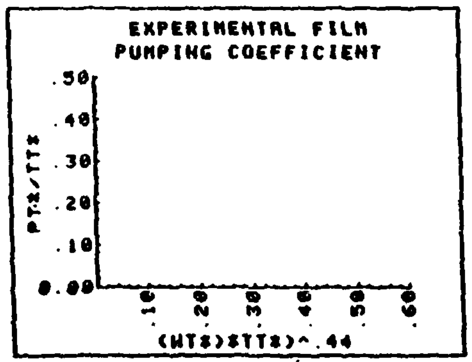
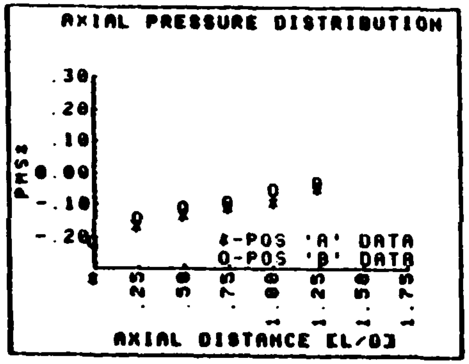


TABLE 30.1 - PCD DATA (CONT) FOR 15/20 NOZZLES WITH L/D=1.5 STACK

MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:				DIAGONAL (POSITION 'B') DATA:			
X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*	X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.440	84	-0.335	0.00	-1.590	84	-0.210
0.25	-1.215	24	-0.167	0.25	-1.060	24	-0.146
0.50	-0.970	22	-0.133	0.50	-0.790	22	-0.109
0.75	-0.800	24	-0.110	0.75	-0.695	24	-0.095
1.00	-0.660	22	-0.091	1.00	-0.375	22	-0.052
1.25	-0.360	12	-0.049	1.25	-0.210	12	-0.029



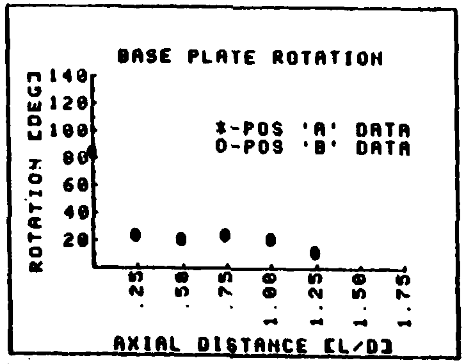
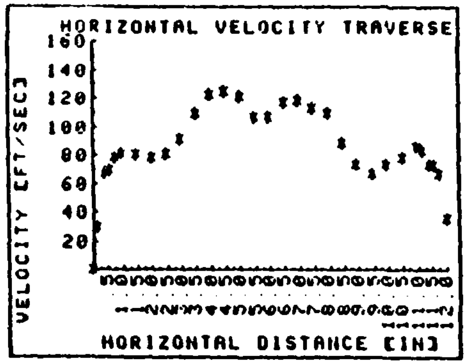


TABLE 30.2 - MSD DATA FOR 15/20 NOZZLES WITH L/D=1.5 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 94 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]:	0.00	0.20	1.00	1.10	1.40	1.50	1.50
V[FT/SEC]:	0.00	29.86	66.77	70.03	79.01	81.78	81.78
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]:	1.40	1.50	1.90	2.70	3.40	3.50	3.30
V[FT/SEC]:	79.01	81.78	92.04	109.72	123.13	124.92	121.30
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]:	2.60	2.60	3.10	3.20	2.90	2.70	1.80
V[FT/SEC]:	107.67	107.67	117.57	119.45	113.71	109.72	89.59
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]:	1.20	1.00	1.20	1.40	1.70	1.60	1.20
V[FT/SEC]:	73.15	66.77	73.15	79.01	87.06	84.46	73.15
POSIT[IN]:	11.60	11.80	12.00				
P[IN H2O]:	1.20	1.00	0.30				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 94 DEGREES

POSIT[IN]:	0.00	0.20	0.40	0.60	0.80	1.00	1.50
P[IN H2O]:	0.00	1.20	3.50	4.00	4.40	4.50	4.60
V[FT/SEC]:	0.00	73.15	124.92	133.55	140.07	141.65	143.22
POSIT[IN]:	2.00	2.50	3.00	3.50	4.00	4.50	5.00
P[IN H2O]:	4.10	3.40	3.10	3.00	3.40	3.50	3.20
V[FT/SEC]:	135.21	123.13	117.57	115.66	123.13	124.92	119.45
POSIT[IN]:	5.50	6.00	6.50	7.00	7.50	8.00	8.50
P[IN H2O]:	2.60	2.70	3.10	3.30	2.90	2.70	2.90
V[FT/SEC]:	107.67	109.72	117.57	121.30	113.71	109.72	113.71
POSIT[IN]:	9.00	9.50	10.00	10.50	11.00	11.20	11.40
P[IN H2O]:	3.20	3.50	4.10	4.20	4.10	3.40	3.10
V[FT/SEC]:	119.45	124.92	135.21	136.85	135.21	123.13	117.57
POSIT[IN]:	11.60	11.80	12.00				
P[IN H2O]:	2.70	2.30	0.40				

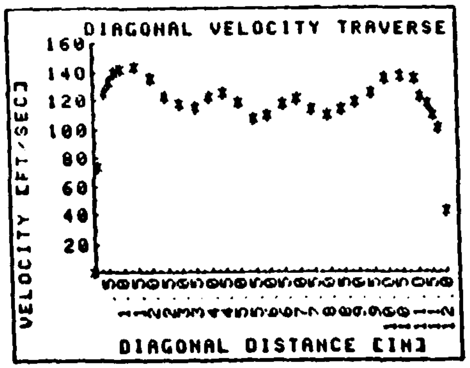


TABLE 30.3 - VTD DATA FOR 15/20 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 23 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.0	58.4	112.2	71.0	3.30	3.09	0.00	0.000	*******
2	0.70	21.9	58.4	112.2	71.0	4.20	2.16	0.00	12.566	*******
3	0.71	22.1	58.4	112.2	71.0	4.80	1.57	0.00	25.133	*******
4	0.70	22.0	58.2	112.0	71.2	5.45	0.86	0.00	50.265	*******
5	0.70	21.9	58.8	112.2	71.2	6.00	0.31	0.00	100.531	*******
6	0.70	22.1	58.4	112.2	71.2	6.15	0.16	0.00	150.796	*******
7	0.70	22.0	58.4	112.0	71.4	6.30	0.01	0.00	*******	*******

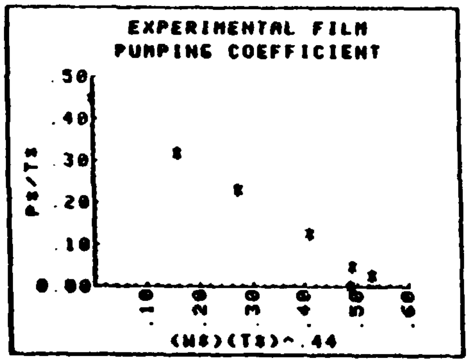
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4100	0.9280	0.4505	0.0000	3.7476	0.0000	181.59	72.64	72.64	0.062
2	0.1685	0.2949	0.9280	0.3178	0.1630	3.7391	0.6299	180.76	83.55	72.31	0.062
3	0.2859	0.2130	0.9280	0.2296	0.2767	3.7561	1.0741	181.32	91.70	72.53	0.062
4	0.4241	0.1177	0.9286	0.1268	0.4105	3.7484	1.5895	180.56	100.61	72.23	0.062
5	0.5107	0.0428	0.9283	0.0461	0.4942	3.7377	1.9087	179.87	106.04	71.95	0.061
6	0.5476	0.0219	0.9283	0.0236	0.5300	3.7562	2.0569	180.69	109.01	72.28	0.062
7	******	0.0007	0.9290	0.0007	******	3.7477	1.0925	180.15	******	72.07	0.061

TABLE 31 - PCD DATA FOR 15/30 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9280	0.0000	*******	3.748	*******	******
2	******	0.0000	0.9280	0.0000	*******	4.369	*******	******
3	******	0.0000	0.9280	0.0000	*******	4.830	*******	******
4	******	0.0000	0.9286	0.0000	*******	5.338	*******	******
5	******	0.0000	0.9283	0.0000	*******	5.646	*******	******
6	******	0.0000	0.9283	0.0000	*******	5.813	*******	******
7	******	0.0000	0.9290	0.0000	*******	******	*******	******



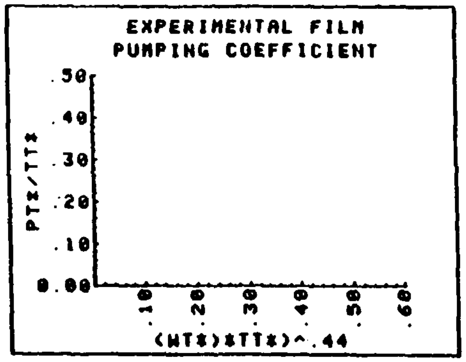


TABLE 31.1 - PCD DATA (CONT) FOR 15/30 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:

LENGTH:	17.55	[IN]
DIAMETER:	11.70	[IN]
L/D RATIO:	1.50	
S/D RATIO:	0.50	

PRIMARY NOZZLE INFORMATION:

TILT ANGLE:	20.0	[DEG]
ROTATION ANGLE:	10	[DEG]
AREA PER NOZZLE:	10.752	[IN2]
NUMBER OF NOZZLES:	4	

MISCELLANEOUS INFORMATION:

ORIFICE DIAMETER:	6.902	[IN]
ORIFICE BETA:	0.497	
UPTAKE AREA:	107.510	[IN2]
ATM. PRESSURE:	30.03	[INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	57.6	111.6	72.0	3.80	2.06	0.00	0.000	*******
2	0.70	22.0	57.0	111.4	71.6	4.45	1.97	0.00	12.566	*******
3	0.70	22.1	57.0	111.6	71.6	4.35	1.44	0.00	25.133	*******
4	0.70	22.1	57.6	111.6	71.6	5.55	0.09	0.00	50.265	*******
5	0.70	22.0	57.6	111.6	71.6	6.00	0.30	0.00	100.531	*******
6	0.70	22.0	57.2	111.2	71.0	6.15	0.16	0.00	150.796	*******
7	0.70	22.0	57.2	111.2	71.0	6.25	0.01	0.00	*******	*******

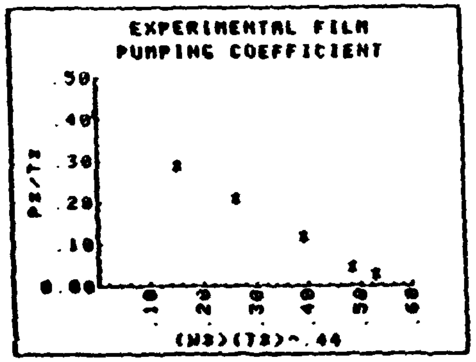
SECONDARY BOX

N	W*	P*	T*	P*/T* W*T^.44		WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3865	0.9307	0.4153	0.0000	3.7590	0.0000	101.84	72.74	72.74	0.062
2	0.1602	0.2683	0.9303	0.2884	0.1552	3.7527	0.6012	101.08	83.18	72.44	0.062
3	0.2735	0.1959	0.9300	0.2107	0.2649	3.7583	1.0281	101.17	90.85	72.48	0.062
4	0.4077	0.1091	0.9300	0.1174	0.3949	3.7591	1.5325	100.92	99.76	72.38	0.062
5	0.5004	0.0412	0.9300	0.0443	0.4847	3.7505	1.8769	100.29	105.66	72.12	0.062
6	0.5479	0.0220	0.9310	0.0237	0.5309	3.7520	2.0557	100.10	108.82	72.08	0.062
7	******	0.0014	0.9310	0.0015	******	3.7520	2.6753	100.11	******	72.05	0.062

TABLE 32 - PCD DATA FOR 20/10 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	VE FT/SEC
1	******	0.0000	0.9307	0.0000	*******	3.759	*******	******
2	******	0.0000	0.9303	0.0000	*******	4.354	*******	******
3	******	0.0000	0.9300	0.0000	*******	4.786	*******	******
4	******	0.0000	0.9300	0.0000	*******	5.292	*******	******
5	******	0.0000	0.9300	0.0000	*******	5.627	*******	******
6	******	0.0000	0.9310	0.0000	*******	5.808	*******	******
7	******	0.0000	0.9310	0.0000	*******	******	*******	******



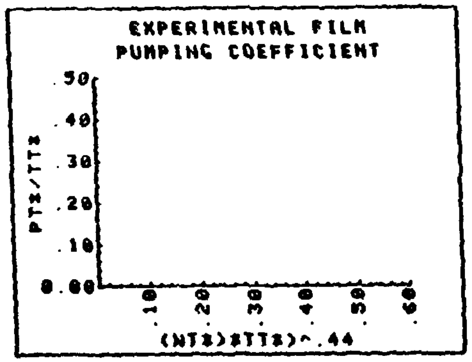


TABLE 32.1 - PCD DATA (CONT) FOR 20/10 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	57.4	111.4	71.6	3.55	2.94	0.00	0.000	*******
2	0.70	22.1	57.2	111.2	71.4	4.25	2.14	0.00	12.566	*******
3	0.70	22.0	57.0	111.0	71.4	4.80	1.51	0.00	25.133	*******
4	0.70	22.1	57.4	111.4	71.4	5.45	0.83	0.00	50.265	*******
5	0.70	22.0	57.2	111.4	71.4	5.90	0.31	0.00	100.531	*******
6	0.70	22.1	57.0	111.6	71.4	6.10	0.16	0.00	150.796	*******
7	0.70	22.0	57.0	111.6	71.6	6.25	0.01	0.00	*******	*******

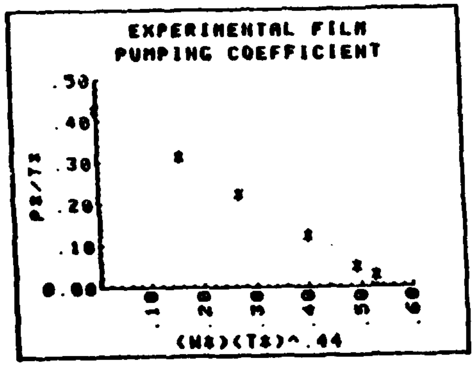
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3952	0.9303	0.4248	0.0000	3.7683	0.0000	102.26	72.91	72.91	0.062
2	0.1667	0.2901	0.9303	0.3119	0.1614	3.7605	0.6267	101.46	83.79	72.59	0.062
3	0.2806	0.2063	0.9306	0.2217	0.2718	3.7527	1.0529	100.75	91.11	72.30	0.062
4	0.4153	0.1132	0.9300	0.1217	0.4022	3.7598	1.5613	100.91	100.26	72.37	0.062
5	0.5086	0.0426	0.9300	0.0458	0.4926	3.7520	1.9083	100.31	106.22	72.13	0.062
6	0.5472	0.0219	0.9296	0.0236	0.5299	3.7503	2.0565	100.61	108.90	72.25	0.062
7	******	0.0014	0.9300	0.0015	******	3.7490	2.6758	100.13	******	72.06	0.062

TABLE 33 - PCD DATA FOR 20/20 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9303	0.0000	*******	3.768	*******	******
2	******	0.0000	0.9303	0.0000	*******	4.387	*******	******
3	******	0.0000	0.9306	0.0000	*******	4.806	*******	******
4	******	0.0000	0.9300	0.0000	*******	5.321	*******	******
5	******	0.0000	0.9300	0.0000	*******	5.660	*******	******
6	******	0.0000	0.9296	0.0000	*******	5.815	*******	******
7	******	0.0000	0.9300	0.0000	*******	******	*******	******



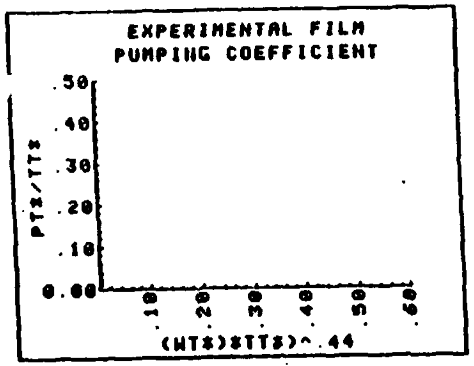


TABLE 33.1 - PCD DATA (CONT) FOR 20/20 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.982 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.0	57.4	111.4	71.2	3.20	3.07	0.00	0.000	*******
2	0.71	22.2	57.6	111.4	71.2	4.15	2.20	0.00	12.566	*******
3	0.71	22.2	57.0	111.2	71.2	4.75	1.57	0.00	25.133	*******
4	0.70	22.0	56.0	111.2	71.2	5.35	0.87	0.00	50.265	*******
5	0.70	22.1	57.2	111.2	71.2	5.95	0.33	0.00	100.531	*******
6	0.70	22.1	57.0	111.0	71.2	6.10	0.10	0.00	150.796	*******
7	0.70	22.0	57.0	111.2	71.4	6.25	0.01	0.00	*******	*******

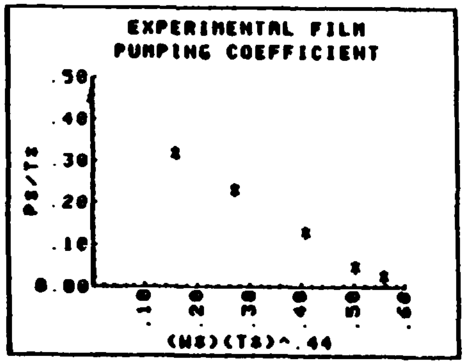
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4159	0.9296	0.4474	0.0000	3.7513	0.0000	101.50	72.60	72.61	0.062
2	0.1587	0.2967	0.9296	0.3192	0.1634	3.7675	0.6356	101.09	84.11	72.76	0.062
3	0.2849	0.2123	0.9299	0.2283	0.2759	3.7697	1.0739	101.65	91.04	72.67	0.062
4	0.4259	0.1191	0.9299	0.1281	0.4125	3.7534	1.5987	100.56	100.70	72.23	0.062
5	0.5237	0.0451	0.9299	0.0485	0.5072	3.7605	1.9693	100.66	107.43	72.27	0.062
6	0.5800	0.0246	0.9303	0.0265	0.5619	3.7612	2.1816	100.57	111.19	72.23	0.062
7	******	0.0014	0.9303	0.0015	******	3.7527	2.6763	100.15	******	72.06	0.062

TABLE 34 - PCD DATA FOR 20/30 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9296	0.0000	*******	3.751	*******	******
2	******	0.0000	0.9296	0.0000	*******	4.403	*******	******
3	******	0.0000	0.9299	0.0000	*******	4.844	*******	******
4	******	0.0000	0.9299	0.0000	*******	5.352	*******	******
5	******	0.0000	0.9299	0.0000	*******	5.730	*******	******
6	******	0.0000	0.9303	0.0000	*******	5.943	*******	******
7	******	0.0000	0.9303	0.0000	*******	******	*******	******



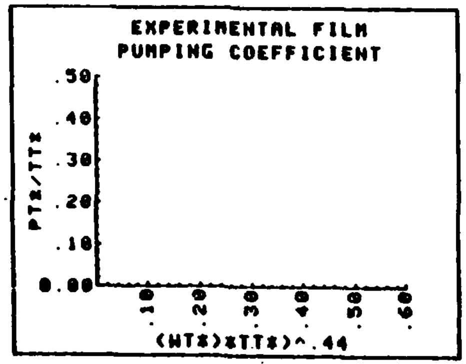


TABLE 34.1 - PCD DATA (CONT) FOR 20/30 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 17.55 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.50
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 22.5 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 30.03 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	56.6	110.6	71.4	4.15	2.78	0.00	0.000	*******
2	0.70	21.9	57.2	110.0	71.2	4.75	1.92	0.00	12.566	*******
3	0.71	22.2	57.0	111.0	71.2	5.35	1.39	0.00	25.133	*******
4	0.70	22.0	56.0	110.0	71.2	5.95	0.77	0.00	50.265	*******
5	0.70	22.0	56.0	110.6	71.2	6.40	0.29	0.00	100.531	*******
6	0.70	22.1	56.4	110.6	71.2	6.60	0.15	0.00	150.796	*******
7	0.70	22.1	56.0	110.6	71.4	6.70	0.01	0.00	*******	*******

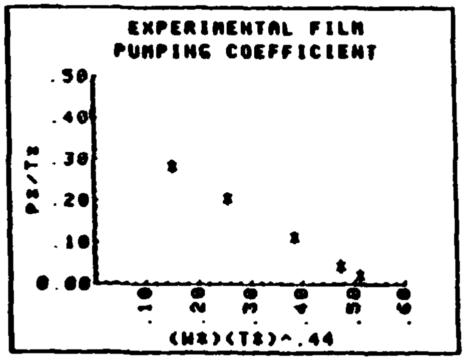
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3760	0.9313	0.4038	0.0000	3.7627	0.0000	101.66	72.67	72.67	0.062
2	0.1506	0.2632	0.9306	0.2828	0.1537	3.7435	0.5937	100.42	82.77	72.17	0.062
3	0.2680	0.1883	0.9303	0.2024	0.2596	3.7697	1.0104	101.51	90.65	72.61	0.062
4	0.4007	0.1056	0.9306	0.1135	0.3882	3.7534	1.5041	100.39	99.02	72.16	0.062
5	0.4915	0.0398	0.9309	0.0428	0.4762	3.7564	1.8461	100.25	105.07	72.11	0.062
6	0.5292	0.0205	0.9309	0.0221	0.5128	3.7634	1.9915	100.53	107.70	72.22	0.062
7	******	0.0014	0.9313	0.0015	******	3.7620	2.6763	100.40	******	72.17	0.062

TABLE 35 - PCD DATA FOR 22.5/10 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9313	0.0000	*******	3.763	*******	******
2	******	0.0000	0.9306	0.0000	*******	4.337	*******	******
3	******	0.0000	0.9303	0.0000	*******	4.780	*******	******
4	******	0.0000	0.9306	0.0000	*******	5.258	*******	******
5	******	0.0000	0.9309	0.0000	*******	5.602	*******	******
6	******	0.0000	0.9309	0.0000	*******	5.755	*******	******
7	******	0.0000	0.9313	0.0000	*******	******	*******	******



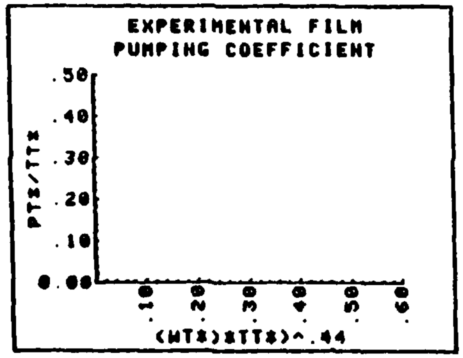


TABLE 35.1 - PCD DATA (CONT) FOR 22.5/10 NOZZLES WITH L/D=1.5

DATA TAKEN ON: 24 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:

LENGTH:	17.55	[IN]
DIAMETER:	11.70	[IN]
L/D RATIO:	1.50	
S/D RATIO:	0.50	

PRIMARY NOZZLE INFORMATION:

TILT ANGLE:	22.5	[DEG]
ROTATION ANGLE:	20	[DEG]
AREA PER NOZZLE:	10.752	[IN2]
NUMBER OF NOZZLES:	4	

MISCELLANEOUS INFORMATION:

ORIFICE DIAMETER:	6.902	[IN]
ORIFICE BETA:	0.497	
UPTAKE AREA:	107.510	[IN2]
ATM. PRESSURE:	30.03	[INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	57.2	110.0	71.2	3.75	2.92	0.00	0.000	*******
2	0.70	22.1	57.0	110.0	71.0	4.55	2.07	0.00	12.566	*******
3	0.70	22.0	57.0	110.0	71.0	5.05	1.46	0.00	25.133	*******
4	0.70	22.1	57.2	110.0	71.2	5.75	0.81	0.00	50.265	*******
5	0.70	22.0	57.0	110.0	71.2	6.20	0.29	0.00	100.531	*******
6	0.70	21.9	57.2	110.0	71.2	6.30	0.16	0.00	150.796	*******
7	0.70	22.2	57.0	110.0	71.2	6.55	0.01	0.00	*******	*******

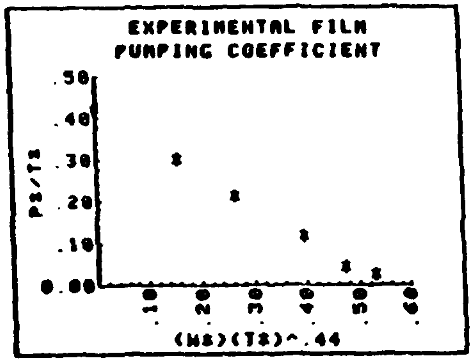
SECONDARY BOX

N	N*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3930	0.9306	0.4223	0.0000	3.7690	0.0000	102.10	72.84	72.85	0.062
2	0.1639	0.2800	0.9302	0.3010	0.1500	3.7612	0.6166	101.34	83.55	72.54	0.062
3	0.2760	0.1995	0.9302	0.2145	0.2674	3.7527	1.0358	100.66	90.76	72.27	0.062
4	0.4102	0.1106	0.9306	0.1189	0.3974	3.7605	1.5426	100.75	99.05	72.31	0.062
5	0.4919	0.0399	0.9306	0.0429	0.4766	3.7527	1.8461	100.14	105.03	72.06	0.062
6	0.5494	0.0221	0.9306	0.0230	0.5323	3.7435	2.0569	179.64	108.59	71.86	0.061
7	******	0.0014	0.9306	0.0015	******	3.7697	2.6760	100.03	******	72.34	0.062

TABLE 36 - PCD DATA FOR 22.5/20 NOZZLES WITH L/D=1.5 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9306	0.0000	*******	3.769	*******	******
2	******	0.0000	0.9302	0.0000	*******	4.370	*******	******
3	******	0.0000	0.9302	0.0000	*******	4.700	*******	******
4	******	0.0000	0.9306	0.0000	*******	5.303	*******	******
5	******	0.0000	0.9306	0.0000	*******	5.599	*******	******
6	******	0.0000	0.9306	0.0000	*******	5.000	*******	******
7	******	0.0000	0.9306	0.0000	*******	******	*******	******



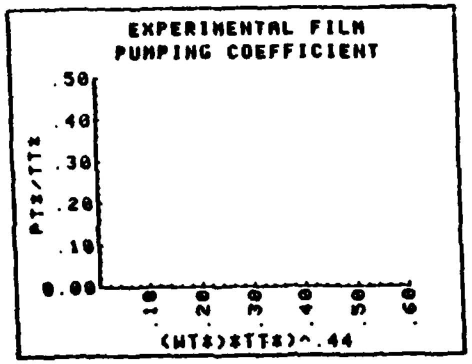


TABLE 36.1 - PCD DATA (CONT) FOR 22.5/20 NOZZLES WITH L/D=1.5 STACK

DATA TAKEN ON: 25 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
STRAIGHT NOZZLE CAL RUN

MIXING STACK INFORMATION:

LENGTH:	14.63	[IN]
DIAMETER:	11.70	[IN]
L/D RATIO:	1.25	
S/D RATIO:	0.50	

PRIMARY NOZZLE INFORMATION:

TILT ANGLE:	0.0	[DEG]
ROTATION ANGLE:	0	[DEG]
AREA PER NOZZLE:	10.752	[IN2]
NUMBER OF NOZZLES:	4	

MISCELLANEOUS INFORMATION:

ORIFICE DIAMETER:	6.902	[IN]
ORIFICE BETA:	0.497	
UPTAKE AREA:	107.510	[IN2]
ATM. PRESSURE:	30.03	[INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.70	22.0	57.2	110.4	66.4	3.35	3.17	0.00	0.000	*******
2	0.70	22.1	57.0	110.6	66.6	4.40	2.04	0.00	12.566	*******
3	0.70	22.0	58.0	110.6	66.0	5.00	1.37	0.00	25.133	*******
4	0.70	22.1	57.0	110.8	66.8	5.62	0.73	0.00	50.265	*******
5	0.70	22.0	57.2	110.0	67.2	6.05	0.26	0.00	100.531	*******
6	0.70	22.1	57.0	111.0	67.4	6.20	0.13	0.00	150.796	*******
7	0.70	22.1	57.0	111.0	68.2	6.32	0.01	0.00	*******	*******

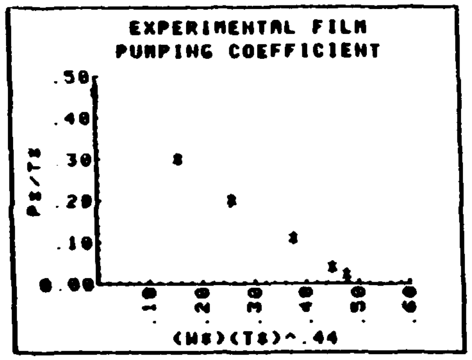
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4267	0.9228	0.4623	0.0000	3.7520	0. 000	181.26	72.51	72.51	0.062
2	0.1536	0.2751	0.9220	0.2981	0.1579	3.7503	0.6147	181.12	83.34	72.46	0.062
3	0.2607	0.1863	0.9232	0.2018	0.2594	3.7491	1.0073	180.38	90.00	72.16	0.062
4	0.3913	0.0990	0.9229	0.1073	0.3777	3.7503	1.4706	180.61	98.29	72.25	0.062
5	0.4676	0.0355	0.9236	0.0384	0.4516	3.7520	1.7546	180.09	103.14	72.04	0.062
6	0.4951	0.0177	0.9236	0.0192	0.4781	3.7503	1.8607	180.40	105.15	72.17	0.062
7	******	0.0014	0.9250	0.0015	******	3.7503	2.6844	180.35	******	72.15	0.062

TABLE 37 - PCD DATA FOR STRAIGHT NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9228	0.0000	*******	3.752	*******	******
2	******	0.0000	0.9228	0.0000	*******	4.373	*******	******
3	******	0.0000	0.9232	0.0000	*******	4.756	*******	******
4	******	0.0000	0.9229	0.0000	*******	5.229	*******	******
5	******	0.0000	0.9236	0.0000	*******	5.507	*******	******
6	******	0.0000	0.9236	0.0000	*******	5.619	*******	******
7	******	0.0000	0.9250	0.0000	*******	******	*******	******



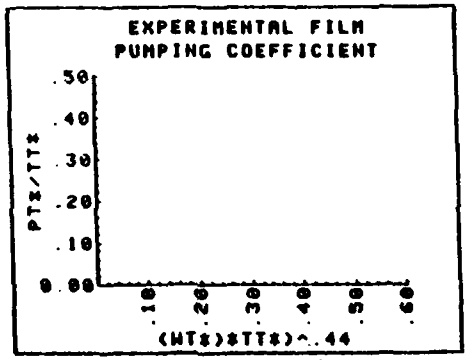
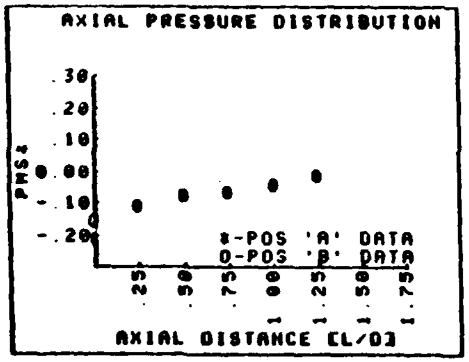


TABLE 37.1 - PCD DATA (CONT) FOR STRAIGHT NOZZLES WITH L/D=1.25 STACK

MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA				DIAGONAL (POSITION 'B') DATA			
X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*	X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.570	45	-0.214	0.00	-1.145	45	-0.156
0.25	-0.825	45	-0.113	0.25	-0.805	45	-0.110
0.50	-0.570	45	-0.078	0.50	-0.560	45	-0.076
0.75	-0.475	45	-0.065	0.75	-0.465	45	-0.063
1.00	-0.285	45	-0.039	1.00	-0.300	45	-0.041
1.25	-0.105	45	-0.014	1.25	-0.115	45	-0.016



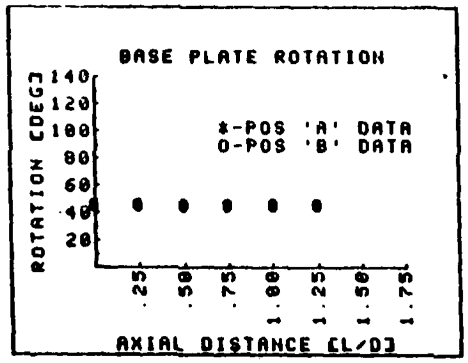
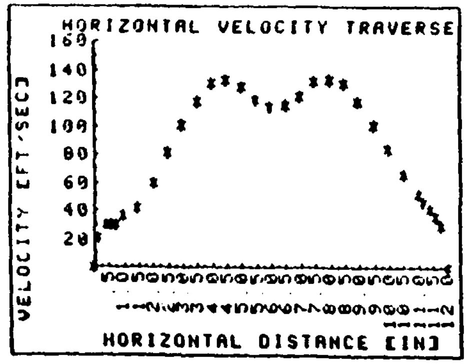


TABLE 37.2 - MSD DATA FOR STRAIGHT NOZZLES WITH L/D=1.25 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.10	0.20	0.20	0.20	0.30	0.40
VE[FT/SEC]	0.00	21.06	29.79	29.79	29.79	36.49	42.13
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	0.90	1.50	2.30	3.10	3.80	4.00	3.70
VE[FT/SEC]	59.58	81.58	101.02	117.28	129.85	133.22	128.13
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	3.20	2.90	3.00	3.30	3.90	4.00	3.80
VE[FT/SEC]	119.16	113.44	115.38	121.01	131.55	133.22	129.85
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	3.10	2.30	1.60	1.00	0.60	0.50	0.40
VE[FT/SEC]	117.28	101.02	84.26	66.61	51.60	47.10	42.13
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	0.30	0.20	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 00 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PE[IN H2O]	0.00	0.30	0.65	0.80	1.00	1.20	2.10
VE[FT/SEC]	0.00	36.49	53.70	59.58	66.61	72.97	96.53
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PE[IN H2O]	3.60	5.40	6.70	6.70	5.70	4.60	3.70
VE[FT/SEC]	126.39	154.79	172.42	172.42	159.03	142.87	128.13
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PE[IN H2O]	3.20	2.80	2.90	3.20	3.80	4.70	5.80
VE[FT/SEC]	119.16	111.46	113.44	119.16	129.85	144.41	160.42
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PE[IN H2O]	6.60	6.90	6.20	4.80	3.20	2.60	2.20
VE[FT/SEC]	171.13	174.90	165.86	145.94	119.16	107.41	98.80
POSIT[IN]	11.60	11.80	12.00				
PE[IN H2O]	1.90	1.60	0.00				

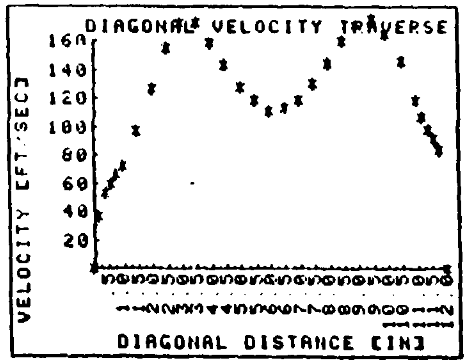


TABLE 37.3 - VTD DATA FOR STRAIGHT NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.98 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	59.2	113.0	71.0	3.20	3.15	0.00	0.000	*******
2	0.71	22.2	59.2	112.0	71.0	4.20	2.19	0.00	12.566	*******
3	0.71	22.0	59.2	112.0	71.0	4.80	1.53	0.00	25.133	*******
4	0.71	22.0	59.2	112.6	71.0	5.50	0.83	0.00	50.265	*******
5	0.71	32.0	59.2	112.6	72.0	6.00	0.30	0.00	100.531	*******
6	0.71	22.0	59.4	112.0	72.0	6.10	0.15	0.00	150.796	*******
7	0.71	22.0	59.2	112.8	72.2	6.20	0.01	0.00	*******	*******

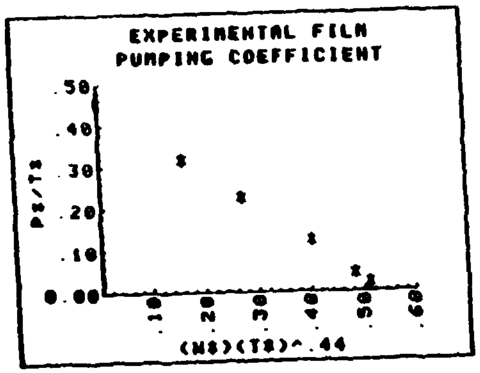
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4261	0.9281	0.4592	0.0000	3.7416	0.0000	181.88	72.76	72.76	0.062
2	0.1685	0.2952	0.9284	0.3180	0.1631	3.7586	0.6332	182.21	84.23	72.89	0.062
3	0.2829	0.2088	0.9284	0.2249	0.2738	3.7416	1.0586	181.09	91.40	72.44	0.062
4	0.4168	0.1137	0.9287	0.1225	0.4034	3.7416	1.5594	180.72	100.21	72.29	0.062
5	0.50[illegible]	0.0412	0.9291	0.0444	0.4851	3.7416	1.8747	180.48	105.78	72.20	0.062
6	0.5315	0.0206	0.9287	0.0222	0.5145	3.7409	1.9884	180.44	107.80	72.10	0.062
7	******	0.0014	0.9291	0.0015	******	3.7416	2.6721	180.41	******	72.17	0.062

TABLE 38 - PCD DATA FOR 10/10 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	VE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9291	0.0000	*******	3.742	*******	******
2	******	0.0000	0.9284	0.0000	*******	4.392	*******	******
3	******	0.0000	0.9284	0.0000	*******	4.800	*******	******
4	******	0.0000	0.9287	0.0000	*******	5.301	*******	******
5	******	0.0000	0.9291	0.0000	*******	5.616	*******	******
6	******	0.0000	0.9287	0.0000	*******	5.729	*******	******
7	******	0.0000	0.9291	0.0000	*******	******	*******	******



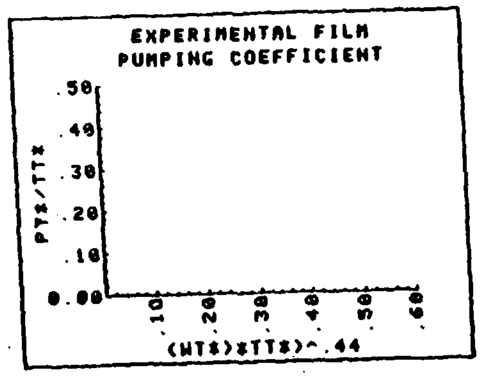


TABLE 38.1 - PCD DATA (CONT) FOR 10/10 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	59.0	112.0	72.2	3.30	3.00	0.00	0.000	*******
2	0.71	22.0	59.0	112.0	72.2	4.30	2.03	0.00	12.566	*******
3	0.71	22.1	59.0	112.6	72.2	5.00	1.42	0.00	25.133	*******
4	0.71	22.0	59.0	112.6	72.2	5.60	0.74	0.00	50.265	*******
5	0.71	22.1	59.2	112.0	72.2	6.00	0.26	0.00	100.531	*******
6	0.70	22.0	58.4	112.6	72.4	6.15	0.07	0.00	150.796	*******
7	0.71	22.0	59.2	112.6	72.4	6.25	0.01	0.00	*******	*******

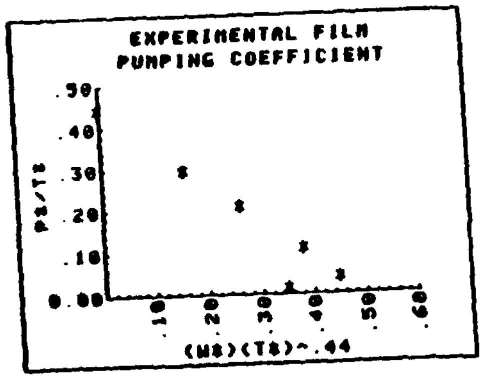
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4135	0.9291	0.4450	0.0000	3.7599	0.0000	102.61	73.05	73.05	0.062
2	0.1628	0.2764	0.9291	0.2975	0.1577	3.7430	0.6095	101.32	83.45	72.53	0.062
3	0.2710	0.1932	0.9294	0.2079	0.2632	3.7514	1.0196	101.39	90.83	72.56	0.062
4	0.3933	0.1015	0.9294	0.1092	0.3800	3.7429	1.4721	100.60	98.65	72.20	0.062
5	0.4653	0.0356	0.9291	0.0383	0.4505	3.7507	1.7452	100.90	103.63	72.37	0.062
6	0.3626	0.0096	0.9290	0.0104	0.3512	3.7451	1.3580	100.49	96.54	72.20	0.062
7	******	0.0014	0.9290	0.0015	******	3.7422	2.6720	100.32	******	72.14	0.062

TABLE 30 - PCD DATA FOR 10/20 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9291	0.0000	*******	3.760	*******	******
2	******	0.0000	0.9291	0.0000	*******	4.352	*******	******
3	******	0.0000	0.9294	0.0000	*******	4.771	*******	******
4	******	0.0000	0.9294	0.0000	*******	5.215	*******	******
5	******	0.0000	0.9291	0.0000	*******	5.496	*******	******
6	******	0.0000	0.9298	0.0000	*******	5.103	*******	******
7	******	0.0000	0.9298	0.0000	*******	******	*******	******



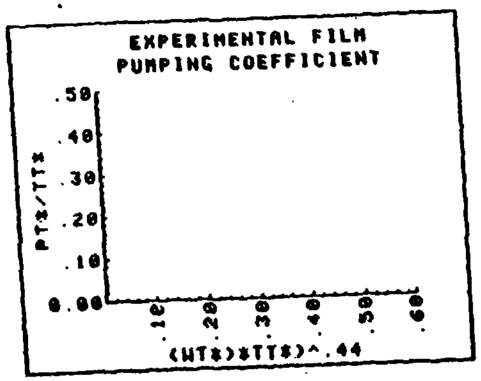


TABLE 30.1 - PCD DATA (CONT) FOR 10/20 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	59.0	112.6	72.4	3.40	2.95	0.00	0.000	*******
2	0.71	22.0	59.0	112.6	72.4	4.45	1.87	0.00	12.566	*******
3	0.71	22.0	59.0	112.6	72.2	5.10	1.27	0.00	25.133	*******
4	0.71	22.0	59.0	112.6	72.4	5.60	0.65	0.00	50.265	*******
5	0.70	22.0	59.0	112.0	72.4	6.00	0.23	0.00	100.531	*******
6	0.70	22.0	58.0	112.6	72.4	6.10	0.11	0.00	150.796	*******
7	0.70	21.9	58.6	112.6	72.4	6.20	0.01	0.00	*******	*******

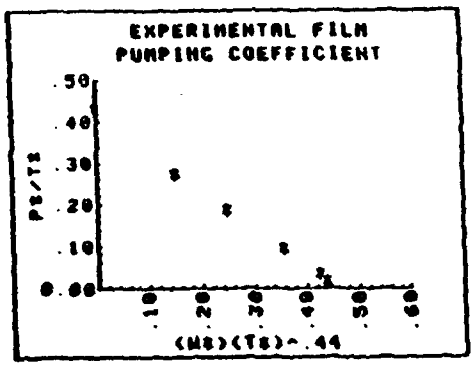
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4003	0.9298	0.4306	0.0000	3.7430	0.0000	101.67	72.67	72.67	0.062
2	0.1563	0.2551	0.9298	0.2744	0.1513	3.7430	0.5849	101.10	82.96	72.48	0.062
3	0.2576	0.1737	0.9294	0.1869	0.2495	3.7430	0.9643	100.92	89.65	72.37	0.062
4	0.3685	0.0892	0.9298	0.0960	0.3569	3.7430	1.3794	100.64	96.90	72.26	0.062
5	0.4385	0.0316	0.9294	0.0340	0.4246	3.7430	1.6411	100.52	101.62	72.21	0.062
6	0.4547	0.0151	0.9290	0.0163	0.4404	3.7437	1.7024	100.44	102.69	72.10	0.062
7	******	0.0014	0.9290	0.0015	******	3.7359	2.6720	100.02	******	72.01	0.061

TABLE 40 - PCD DATA FOR 10/30 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9298	0.0000	*******	3.743	*******	******
2	******	0.0000	0.9298	0.0000	*******	4.328	*******	******
3	******	0.0000	0.9294	0.0000	*******	4.707	*******	******
4	******	0.0000	0.9298	0.0000	*******	5.122	*******	******
5	******	0.0000	0.9294	0.0000	*******	5.384	*******	******
6	******	0.0000	0.9298	0.0000	*******	5.446	*******	******
7	******	0.0000	0.9298	0.0000	*******	******	*******	******



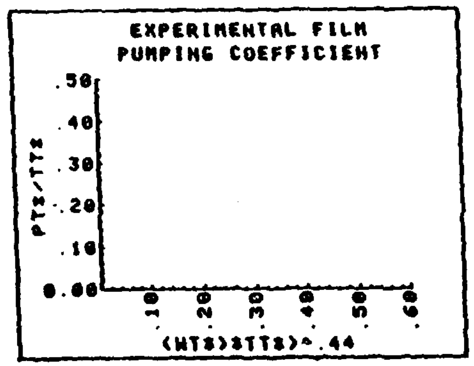


TABLE 40.1 - PCD DATA (CONT) FOR 10/30 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
10 TILT/40 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 10.0 [DEG]
ROTATION ANGLE: 40 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	50.6	112.4	72.4	3.70	2.00	0.00	0.000	*******
2	0.71	22.0	50.6	112.4	72.4	4.65	1.60	0.00	12.566	*******
3	0.71	22.0	50.0	112.4	72.4	5.20	1.11	0.00	25.133	*******
4	0.71	22.0	50.6	112.4	72.4	5.80	0.56	0.00	50.265	*******
5	0.71	22.0	50.4	112.4	72.4	6.15	0.19	0.00	100.531	*******
6	0.71	22.0	50.4	112.4	72.6	6.25	0.10	0.00	150.796	*******
7	0.71	22.0	50.2	112.2	72.6	6.30	0.01	0.00	*******	*******

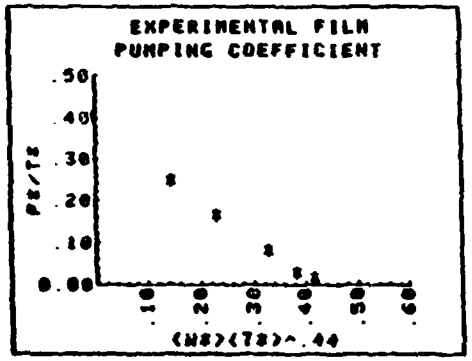
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3768	0.9301	0.4051	0.0000	3.7614	0.0000	182.43	72.98	72.98	0.062
2	0.1481	0.2294	0.9301	0.2466	0.1434	3.7444	0.5544	181.10	82.38	72.45	0.062
3	0.2408	0.1520	0.9301	0.1635	0.2332	3.7437	0.9013	180.82	88.48	72.33	0.062
4	0.3419	0.0769	0.9301	0.0827	0.3312	3.7444	1.2804	180.61	95.19	72.25	0.062
5	0.3983	0.0261	0.9301	0.0281	0.3858	3.7451	1.4916	180.48	98.93	72.20	0.062
6	0.4333	0.0130	0.9304	0.0140	0.4198	3.7451	1.6229	180.44	101.27	72.18	0.062
7	******	0.0014	0.9300	0.0015	******	3.7458	2.6715	180.37	******	72.15	0.062

TABLE 41 - PCD DATA FOR 10/40 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9301	0.0000	*******	3.761	*******	******
2	******	0.0000	0.9301	0.0000	*******	4.299	*******	******
3	******	0.0000	0.9301	0.0000	*******	4.645	*******	******
4	******	0.0000	0.9301	0.0000	*******	5.025	*******	******
5	******	0.0000	0.9301	0.0000	*******	5.237	*******	******
6	******	0.0000	0.9304	0.0000	*******	5.360	*******	******
7	******	0.0000	0.9308	0.0000	*******	******	*******	******



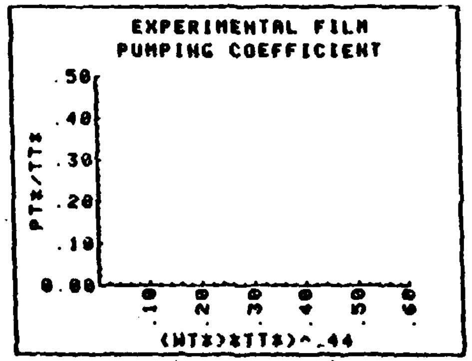


TABLE 41.1 - PCD DATA (CONT) FOR 10/40 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	58.2	112.2	72.4	3.45	3.10	0.00	0.000	*******
2	0.71	22.1	58.2	112.0	72.4	4.20	2.20	0.00	12.566	*******
3	0.70	22.0	58.6	112.0	72.4	4.80	1.56	0.00	25.133	*******
4	0.71	22.2	57.6	112.0	72.4	5.45	0.88	0.00	50.265	*******
5	0.71	22.1	58.4	112.2	72.4	5.95	0.33	0.00	100.531	*******
6	0.70	22.0	58.2	112.0	72.4	6.10	0.17	0.00	150.796	*******
7	0.70	22.0	58.0	112.0	72.4	6.25	0.01	0.00	*******	*******

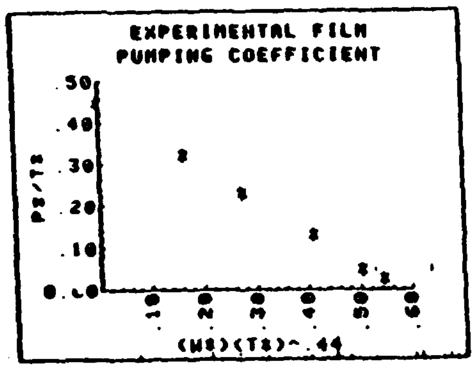
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4165	0.9304	0.4477	0.0000	3.7628	0.0000	102.57	73.03	73.04	0.062
2	0.1630	0.2995	0.9307	0.3207	0.1637	3.7543	0.6344	101.69	84.05	72.60	0.062
3	0.2854	0.2134	0.9307	0.2293	0.2765	3.7444	1.0685	100.93	91.52	72.38	0.062
4	0.4263	0.1195	0.9307	0.1284	0.4130	3.7650	1.6050	101.62	101.41	72.65	0.062
5	0.5237	0.0452	0.9304	0.0485	0.5073	3.7536	1.9658	100.89	107.59	72.36	0.062
6	0.5650	0.0234	0.9307	0.0251	0.5474	3.7459	2.1164	100.30	110.08	72.16	0.062
7	******	0.0014	0.9307	0.0015	******	3.7466	2.6720	100.34	******	72.14	0.062

TABLE 42 - PCD DATA FOR 15/10 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9304	0.0000	*******	3.763	*******	******
2	******	0.0000	0.9307	0.0000	*******	4.389	*******	******
3	******	0.0000	0.9307	0.0000	*******	4.813	*******	******
4	******	0.0000	0.9307	0.0000	*******	5.370	*******	******
5	******	0.0000	0.9304	0.0000	*******	5.719	*******	******
6	******	0.0000	0.9307	0.0000	*******	5.862	*******	******
7	******	0.0000	0.9307	0.0000	*******	******	*******	******



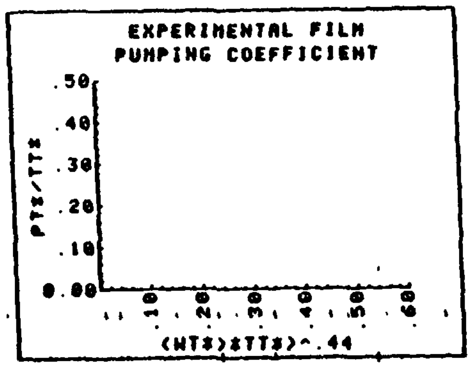


TABLE 42.1 - PCD DATA (CONT) FOR 15/10 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	58.0	112.0	72.4	3.25	3.13	0.00	0.000	*******
2	0.70	22.0	58.0	112.0	72.4	4.15	2.20	0.00	12.566	*******
3	0.71	22.1	57.6	112.0	72.2	4.80	1.57	0.00	25.133	*******
4	0.70	22.0	58.0	112.0	72.4	5.45	0.85	0.00	50.265	*******
5	0.71	22.2	58.2	112.0	72.4	6.00	0.31	0.00	100.531	*******
6	0.70	22.1	58.2	112.0	72.4	6.15	0.16	0.00	150.796	*******
7	0.71	22.0	58.0	112.0	72.4	6.25	0.01	0.00	*******	*******

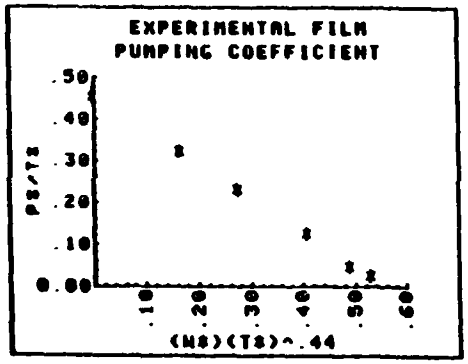
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4206	0.9307	0.4519	0.0000	3.7636	0.0000	102.56	73.03	73.03	0.062
2	0.1693	0.2997	0.9307	0.3220	0.1641	3.7466	0.6344	101.32	83.90	72.53	0.062
3	0.2854	0.2133	0.9304	0.2293	0.2765	3.7565	1.0721	101.51	91.02	72.61	0.062
4	0.4210	0.1166	0.9307	0.1252	0.4079	3.7466	1.5774	100.71	100.56	72.29	0.062
5	0.5063	0.0423	0.9307	0.0454	0.4906	3.7620	1.9053	101.26	106.65	72.51	0.062
6	0.5469	0.0219	0.9307	0.0236	0.5299	3.7544	2.0532	100.70	109.11	72.32	0.062
7	******	0.0014	0.9307	0.0015	******	3.7466	2.6720	100.34	******	72.14	0.062

TABLE 43 - PCD DATA FOR 15/20 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9307	0.0000	*******	3.764	*******	******
2	******	0.0000	0.9307	0.0000	*******	4.381	*******	******
3	******	0.0000	0.9304	0.0000	*******	4.829	*******	******
4	******	0.0000	0.9307	0.0000	*******	5.324	*******	******
5	******	0.0000	0.9307	0.0000	*******	5.560	*******	******
6	******	0.0000	0.9307	0.0000	*******	5.808	*******	******
7	******	0.0000	0.9307	0.0000	*******	******	*******	******



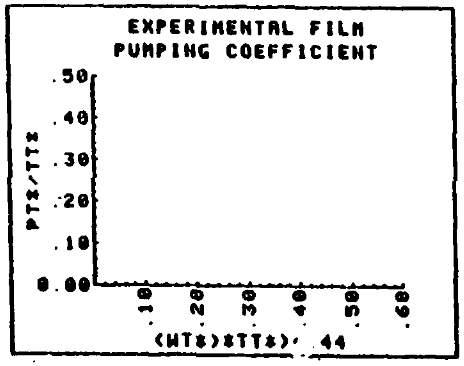


TABLE 43.1 - PCD DATA (CONT) FOR 15/20 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 27 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/20 ROTATION/FULL RUN

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.83 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.0	60.8	113.4	72.4	3.25	3.12	0.00	0.000	*******
2	0.71	22.1	60.6	113.6	72.6	4.20	2.20	0.00	12.566	*******
3	0.70	22.0	60.2	113.4	72.6	4.75	1.57	0.00	25.133	*******
4	0.71	22.2	61.0	113.6	72.8	5.50	0.86	0.00	50.265	*******
5	0.71	22.1	60.8	113.8	72.8	6.00	0.31	0.00	100.531	*******
6	0.71	22.1	61.4	114.4	73.0	6.15	0.16	0.00	150.796	*******
7	0.71	22.1	61.0	114.4	73.0	6.30	0.01	0.00	*******	*******

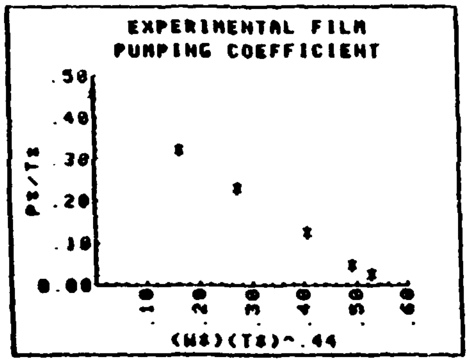
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4233	0.9285	0.4559	0.0000	3.7262	0.0000	182.19	72.88	72.88	0.062
2	0.1693	0.2983	0.9285	0.3212	0.1639	3.7353	0.6326	182.29	84.32	72.92	0.062
3	0.2867	0.2145	0.9288	0.2309	0.2775	3.7283	1.0688	181.60	91.91	72.65	0.062
4	0.4227	0.1170	0.9288	0.1259	0.4091	3.7423	1.5817	182.02	101.34	72.82	0.062
5	0.5086	0.0424	0.9285	0.0457	0.4922	3.7346	1.8993	181.46	106.84	72.59	0.062
6	0.5483	0.0219	0.9279	0.0236	0.5305	3.7325	2.0464	181.40	109.51	72.60	0.062
7	******	0.0014	0.9279	0.0015	******	3.7339	2.6632	181.40	******	72.60	0.062

TABLE 44 - PCD DATA FOR 15/20 NOZZLES WITH L/D=1.25 STACK (FULL RUN)

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9285	0.0000	*******	3.726	*******	******
2	******	0.0000	0.9285	0.0000	*******	4.368	*******	******
3	******	0.0000	0.9288	0.0000	*******	4.797	*******	******
4	******	0.0000	0.9288	0.0000	*******	5.324	*******	******
5	******	0.0000	0.9285	0.0000	*******	5.634	*******	******
6	******	0.0000	0.9279	0.0000	*******	5.779	*******	******
7	******	0.0000	0.9279	0.0000	*******	******	*******	******



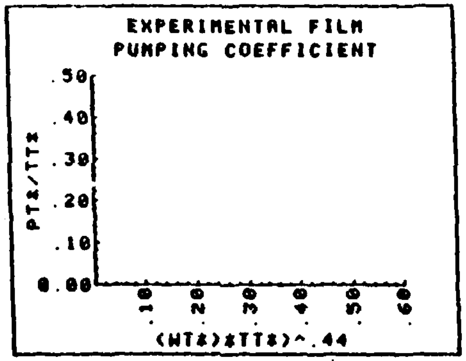


TABLE 44.1 - PCD DATA (CONT) FOR 15/20 NOZZLES WITH L/D=1.25 STACK

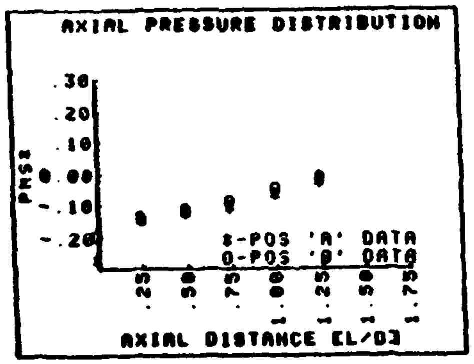
MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.980	92	-0.271
0.25	-1.065	24	-0.146
0.50	-0.880	16	-0.120
0.75	-0.765	12	-0.105
1.00	-0.470	6	-0.064
1.25	-0.165	2	-0.023

DIAGONAL (POSITION 'B') DATA:

X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-1.410	92	-0.193
0.25	-1.005	24	-0.138
0.50	-0.830	16	-0.114
0.75	-0.625	12	-0.086
1.00	-0.335	6	-0.046
1.25	-0.110	2	-0.015



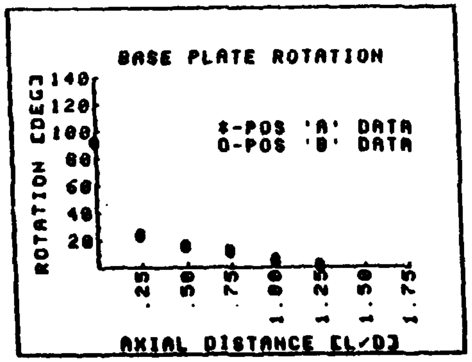
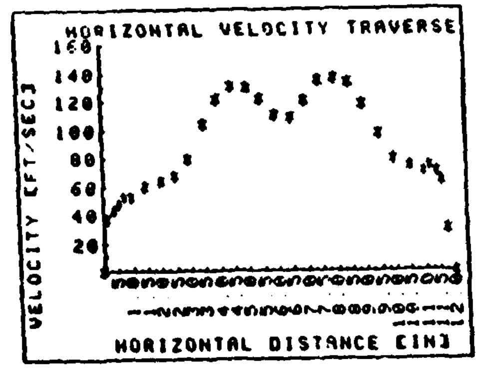


TABLE 44.2 - MSD DATA FOR 15/20 NOZZLES WITH L/D=1.25 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 04 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	0.30	0.40	0.50	0.60	0.60	0.80
VEFT/SEC]	0.00	36.78	42.47	47.48	52.01	52.01	60.06
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	0.90	1.00	1.40	2.40	3.30	3.80	3.70
VEFT/SEC]	63.70	67.14	79.45	104.02	121.97	130.89	129.15
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	3.30	2.70	2.60	3.20	4.00	4.10	3.90
VEFT/SEC]	121.97	110.33	108.27	120.11	134.29	135.96	132.60
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	3.10	2.10	1.40	1.20	1.10	1.20	1.10
VEFT/SEC]	118.22	97.30	79.45	73.55	70.42	73.55	70.42
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	0.90	0.20	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 04 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	1.50	2.40	2.80	3.30	3.70	4.90
VEFT/SEC]	0.00	82.23	104.02	112.35	121.97	129.15	148.63
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	5.50	5.20	4.70	4.10	4.00	4.10	3.80
VEFT/SEC]	157.47	153.11	145.56	135.96	134.29	135.96	130.89
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	3.30	2.70	2.60	3.20	4.00	4.00	3.70
VEFT/SEC]	121.97	110.33	108.27	120.11	134.29	134.29	129.15
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	3.40	3.60	4.20	4.80	4.90	4.90	4.50
VEFT/SEC]	123.81	127.40	137.60	147.11	148.63	148.63	142.43
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	4.00	3.20	0.00				

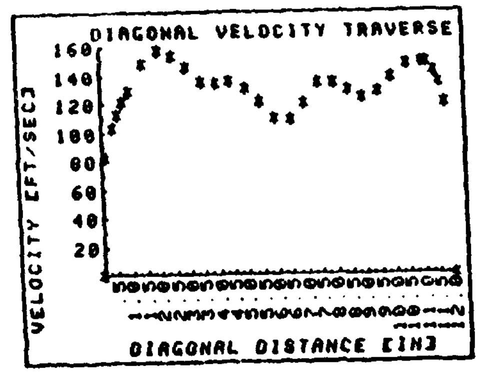


TABLE 44.3 - VTD DATA FOR 15/20 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
15 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 15.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	57.4	111.6	72.0	3.35	3.06	0.00	0.000	*******
2	0.70	21.9	57.4	111.6	72.0	4.25	2.06	0.00	12.566	*******
3	0.71	22.2	57.6	111.0	72.0	4.90	1.47	0.00	25.133	*******
4	0.70	22.0	57.6	111.0	72.0	5.55	0.70	0.00	50.265	*******
5	0.70	21.9	57.0	111.6	72.0	6.05	0.20	0.00	100.531	*******
6	0.70	22.1	50.6	111.0	72.0	6.15	0.14	0.00	150.796	*******
7	0.70	22.0	50.0	112.0	72.0	6.30	0.01	0.00	*******	*******

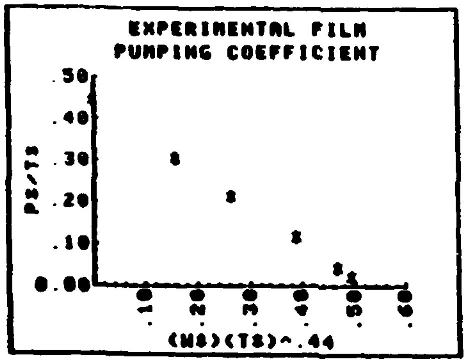
SECONDARY BOX

N	MS	PS	TS	PS/TS	MST^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4130	0.9307	0.4438	0.0000	3.7573	0.0000	102.09	72.04	72.84	0.062
2	0.1642	0.2820	0.9307	0.3030	0.1591	3.7402	0.6141	100.82	83.33	72.33	0.062
3	0.2756	0.1990	0.9304	0.2139	0.2670	3.7650	1.0376	101.82	91.31	72.73	0.062
4	0.4033	0.1069	0.9304	0.1149	0.3907	3.7400	1.5116	100.69	99.35	72.20	0.062
5	0.4841	0.0386	0.9307	0.0415	0.4691	3.7417	1.8114	100.10	104.40	72.05	0.061
6	0.5119	0.0192	0.9304	0.0206	0.4959	3.7529	1.9213	100.64	106.67	72.26	0.062
7	******	0.0014	0.9300	0.0015	******	3.7466	2.6730	100.34	******	72.14	0.062

TABLE 45 - PCD DATA FOR 15/30 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N RUN	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM LBM/SEC	WT LBM/SEC	UE FT/SEC
1	******	0.0000	0.9307	0.0000	*******	3.757	*******	******
2	******	0.0000	0.9307	0.0000	*******	4.354	*******	******
3	******	0.0000	0.9304	0.0000	*******	4.803	*******	******
4	******	0.0000	0.9304	0.0000	*******	5.260	*******	******
5	******	0.0000	0.9307	0.0000	*******	5.553	*******	******
6	******	0.0000	0.9304	0.0000	*******	5.674	*******	******
7	******	0.0000	0.9300	0.0000	*******	******	*******	******



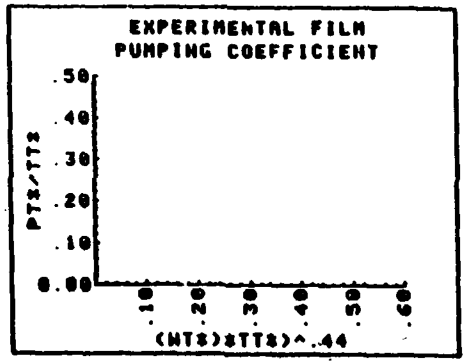


TABLE 45.1 - PCD DATA (CONT) FOR 15/30 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.982 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	58.2	111.0	72.0	3.70	2.03	0.00	0.000	*******
2	0.70	21.9	58.0	111.0	71.0	4.45	1.96	0.00	12.566	*******
3	0.71	22.2	57.0	111.0	72.0	4.95	1.40	0.00	25.133	*******
4	0.70	22.1	57.6	111.0	72.0	5.45	0.79	0.00	50.265	*******
5	0.70	22.0	57.6	111.0	72.0	5.85	0.31	0.00	100.531	*******
6	0.71	22.1	58.0	111.0	72.0	6.05	0.16	0.00	150.796	*******
7	0.71	22.1	58.4	112.0	71.0	6.15	0.01	0.00	*******	*******

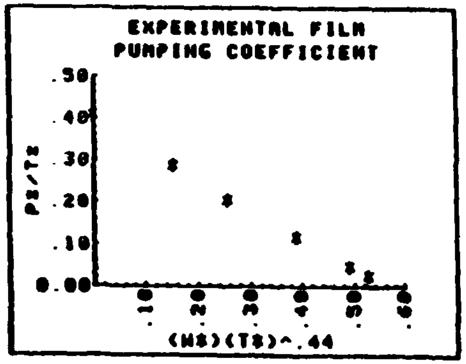
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3827	0.9304	0.4114	0.0000	3.7543	0.0000	101.91	72.77	72.77	0.062
2	0.1603	0.2684	0.9300	0.2886	0.1552	3.7381	0.5992	100.73	83.02	72.30	0.062
3	0.2690	0.1897	0.9304	0.2039	0.2606	3.7643	1.0126	101.75	90.84	72.71	0.062
4	0.4050	0.1078	0.9304	0.1159	0.3923	3.7565	1.5213	101.10	99.69	72.45	0.062
5	0.5085	0.0426	0.9304	0.0458	0.4926	3.7480	1.9060	100.48	106.33	72.20	0.062
6	0.5470	0.0219	0.9304	0.0236	0.5299	3.7551	2.0539	100.75	109.09	72.31	0.062
7	******	0.0014	0.9297	0.0015	******	3.7536	2.6736	100.68	******	72.20	0.062

TABLE 46 - PCD DATA FOR 20/10 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT#	PT#	TT#	PT#/TT#	WT#TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9304	0.0000	*******	3.754	*******	******
2	******	0.0000	0.9300	0.0000	*******	4.337	*******	******
3	******	0.0000	0.9304	0.0000	*******	4.777	*******	******
4	******	0.0000	0.9304	0.0000	*******	5.278	*******	******
5	******	0.0000	0.9304	0.0000	*******	5.654	*******	******
6	******	0.0000	0.9304	0.0000	*******	5.809	*******	******
7	******	0.0000	0.9297	0.0000	*******	******	*******	******



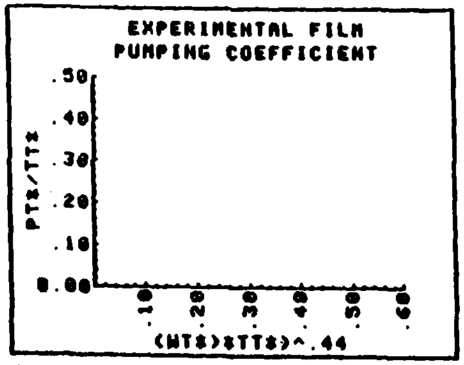


TABLE 46.1 - PCD DATA (CONT) FOR 20/10 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 26 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.1	57.6	111.0	71.0	3.45	2.93	0.00	0.000	*******
2	0.70	22.0	57.4	111.0	71.0	4.15	2.14	0.00	12.566	*******
3	0.70	22.1	57.0	111.6	71.0	4.75	1.55	0.00	25.133	*******
4	0.70	22.0	58.2	111.0	71.0	5.40	0.96	0.00	50.265	*******
5	0.71	22.1	58.0	111.0	71.0	5.95	0.32	0.00	100.531	*******
6	0.71	22.0	58.0	111.0	71.0	6.10	0.17	0.00	150.796	*******
7	0.71	22.0	58.6	112.0	71.0	6.25	0.01	0.00	*******	*******

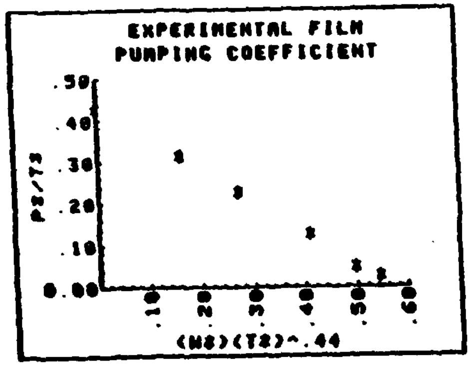
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3954	0.9300	0.4252	0.0000	3.7565	0.0000	102.06	72.83	72.83	0.062
2	0.1670	0.2911	0.9300	0.3131	0.1618	3.7480	0.6261	101.33	83.74	72.54	0.062
3	0.2835	0.2105	0.9303	0.2263	0.2747	3.7587	1.0657	101.49	91.68	72.60	0.062
4	0.4230	0.1179	0.9300	0.1260	0.4105	3.7459	1.5876	100.62	100.67	72.26	0.062
5	0.5150	0.0430	0.9300	0.0471	0.4996	3.7551	1.9368	100.82	107.01	72.34	0.062
6	0.5652	0.0234	0.9300	0.0251	0.5474	3.7466	2.1175	100.35	110.05	72.15	0.062
7	******	0.0014	0.9297	0.0015	******	3.7444	2.6736	100.24	******	72.10	0.062

TABLE 47 - PCD DATA FOR 20/20 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9300	0.0000	*******	3.757	*******	******
2	******	0.0000	0.9300	0.0000	*******	4.375	*******	******
3	******	0.0000	0.9303	0.0000	*******	4.824	*******	******
4	******	0.0000	0.9300	0.0000	*******	5.333	*******	******
5	******	0.0000	0.9300	0.0000	*******	5.692	*******	******
6	******	0.0000	0.9300	0.0000	*******	5.864	*******	******
7	******	0.0000	0.9297	0.0000	*******	******	*******	******



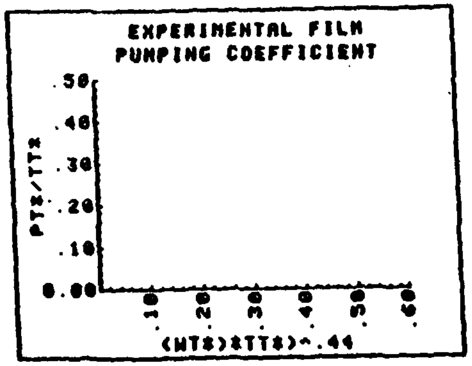


TABLE 47.1 - PCD DATA (CONT) FOR 20/20 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 27 AUG 81
DATA TAKEN BY: DRUCKER/DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/20 ROTATION/FULL

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107 510 [IN2]
ATM. PRESSURE: 29.83 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	59.0	113.0	74.0	3.50	2.93	0.00	0.000	*******
2	0.71	22.2	59.6	113.0	74.0	4.20	2.14	0.00	12.566	*******
3	0.71	22.0	59.6	113.0	74.0	4.75	1.51	0.00	25.133	*******
4	0.71	22.1	59.0	113.2	73.0	5.45	0.85	0.00	50.265	*******
5	0.71	22.0	59.6	113.2	73.6	5.90	0.32	0.00	100.531	*******
6	0.71	22.0	59.4	113.2	73.0	6.05	0.17	0.00	150.796	*******
7	0.71	22.1	59.2	113.0	73.6	6.25	0.01	0.00	*******	*******

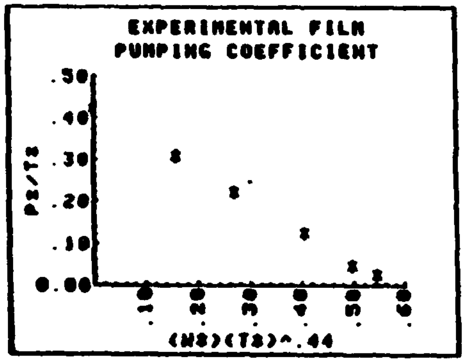
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3947	0.9319	0.4235	0.0000	3.7490	0.0000	103.10	73.25	73.25	0.062
2	0.1663	0.2897	0.9319	0.3109	0.1612	3.7477	0.6231	102.64	84.32	73.06	0.062
3	0.2806	0.2069	0.9319	0.2221	0.2720	3.7308	1.0469	101.53	91.54	72.62	0.062
4	0.4203	0.1163	0.9312	0.1240	0.4073	3.7305	1.5711	101.60	101.06	72.68	0.062
5	0.5169	0.0440	0.9309	0.0473	0.5009	3.7300	1.9284	101.06	107.25	72.43	0.062
6	0.5649	0.0234	0.9312	0.0251	0.5475	3.7315	2.1079	101.03	110.50	72.42	0.062
7	******	0.0014	0.9312	0.0015	******	3.7407	2.6619	101.34	******	72.54	0.062

TABLE 48 - PCD DATA FOR 20/20 NOZZLES WITH L/D=1.25 STACK (FULL RUN)

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9319	0.0000	*******	3.750	*******	******
2	******	0.0000	0.9319	0.0000	*******	4.371	*******	******
3	******	0.0000	0.9319	0.0000	*******	4.778	*******	******
4	******	0.0000	0.9312	0.0000	*******	5.310	*******	******
5	******	0.0000	0.9309	0.0000	*******	5.659	*******	******
6	******	0.0000	0.9312	0.0000	*******	5.839	*******	******
7	******	0.0000	0.9312	0.0000	*******	******	*******	******



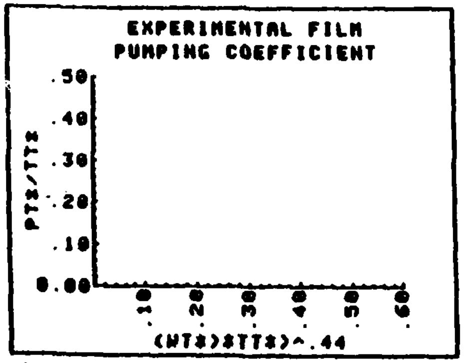
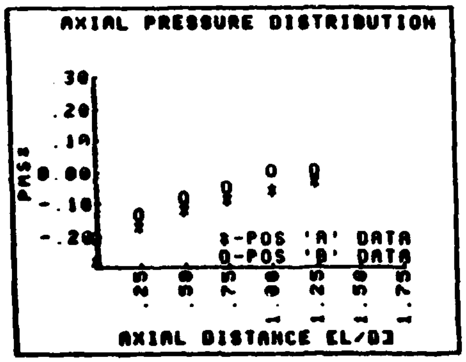


TABLE 48.1 - PCD DATA (CONT) FOR 20/20 NOZZLES WITH L/D=1.25 STACK

MIXING STACK DATA FOR RUN 7

TOP (POSITION 'A') DATA:				DIAGONAL (POSITION 'B') DATA:			
X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*	X/D	PRESSURE [IN H2O]	ROTATION [DEG]	PMS*
0.00	-2.040	92	-0.280	0.00	-1.510	92	-0.207
0.25	-1.245	22	-0.171	0.25	-0.975	22	-0.134
0.50	-0.890	17	-0.122	0.50	-0.595	17	-0.082
0.75	-0.635	16	-0.087	0.75	-0.335	16	-0.046
1.00	-0.410	4	-0.056	1.00	0.040	4	0.005
1.25	-0.210	14	-0.029	1.25	0.040	14	0.005



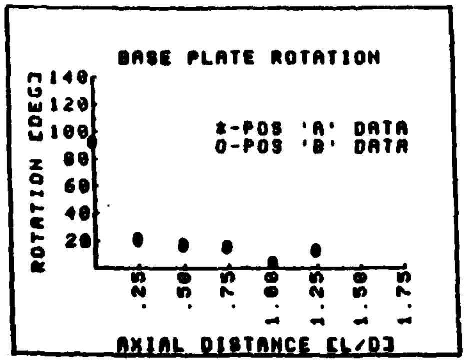
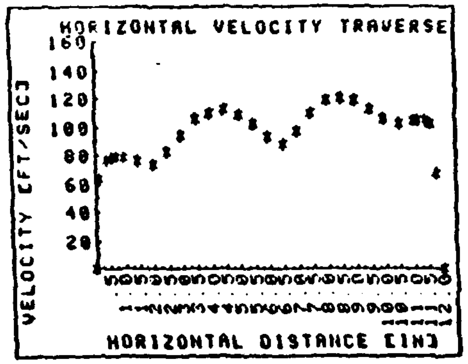


TABLE 48.2 - MSD DATA FOR 20/20 NOZZLES WITH L/D=1.25 STACK

HORIZONTAL VELOCITY TRAVERSE AT BASE ROTATION OF 85 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	0.90	1.30	1.40	1.40	1.40	1.30
VEFT/SEC]	0.00	63.73	76.59	79.40	79.40	79.40	76.59
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	1.20	1.50	2.00	2.50	2.70	2.80	2.60
VEFT/SEC]	73.59	92.27	95.00	106.21	110.39	112.41	103.32
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	2.30	1.90	1.70	2.10	2.70	3.10	3.20
VEFT/SEC]	101.88	92.60	87.59	97.35	110.30	110.28	120.17
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	3.10	2.80	2.50	2.30	2.40	2.40	2.40
VEFT/SEC]	110.28	112.41	106.21	101.88	104.07	104.07	104.07
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	2.30	1.00	0.00				



DIAGONAL VELOCITY TRAVERSE FOR BASE ROTATION OF 85 DEGREES

POSIT[IN]	0.00	0.20	0.40	0.60	0.80	1.00	1.50
PEIN H2O]	0.00	1.20	4.10	4.70	4.90	5.10	4.90
VEFT/SEC]	0.00	73.59	136.02	145.63	148.70	151.71	148.70
POSIT[IN]	2.00	2.50	3.00	3.50	4.00	4.50	5.00
PEIN H2O]	4.30	3.70	3.50	3.30	3.20	2.90	2.50
VEFT/SEC]	139.30	129.22	125.68	122.03	120.17	114.40	106.21
POSIT[IN]	5.50	6.00	6.50	7.00	7.50	8.00	8.50
PEIN H2O]	2.10	1.80	1.80	2.20	2.80	3.10	3.00
VEFT/SEC]	97.35	90.13	90.13	99.64	112.41	110.28	116.35
POSIT[IN]	9.00	9.50	10.00	10.50	11.00	11.20	11.40
PEIN H2O]	2.80	2.50	2.60	3.20	4.30	4.90	5.10
VEFT/SEC]	112.41	106.21	108.32	120.17	139.30	148.70	151.71
POSIT[IN]	11.60	11.80	12.00				
PEIN H2O]	5.10	4.40	0.00				

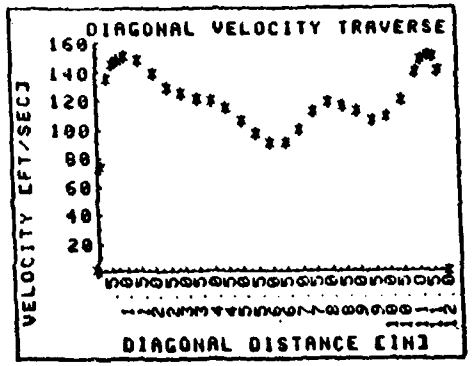


TABLE 48.3 - VTD DATA FOR 20/20 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 27 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
20 TILT/30 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 20.0 [DEG]
ROTATION ANGLE: 30 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.99 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	58.0	111.0	71.6	3.20	3.14	0.00	0.000	*******
2	0.71	22.1	57.0	111.0	71.6	4.10	2.20	0.00	12.566	*******
3	0.70	22.0	57.0	111.0	71.6	4.65	1.50	0.00	25.133	*******
4	0.70	22.0	57.0	111.6	71.6	5.35	0.60	0.00	50.265	*******
5	0.71	22.1	57.6	111.6	71.6	5.90	0.33	0.00	100.531	*******
6	0.70	22.1	57.2	111.4	71.6	6.05	0.17	0.00	150.796	*******
7	0.70	22.0	56.6	111.2	71.6	6.20	0.01	0.00	*******	*******

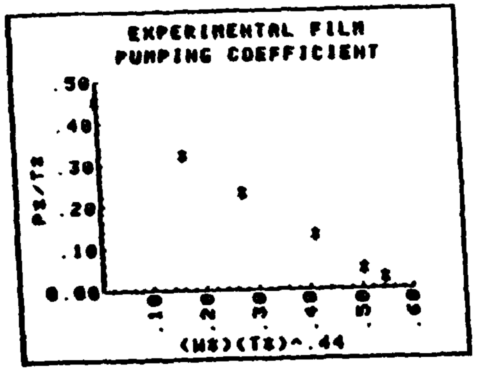
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.4216	0.9297	0.4535	0.0000	3.7636	0.0000	102.50	73.00	73.01	0.062
2	0.1690	0.2980	0.9297	0.3205	0.1637	3.7558	0.6349	101.70	84.04	72.69	0.062
3	0.2872	0.2156	0.9297	0.2320	0.2781	3.7473	1.0762	101.01	91.67	72.41	0.062
4	0.4283	0.1204	0.9300	0.1295	0.4140	3.7502	1.6062	100.70	101.06	72.32	0.062
5	0.5237	0.0451	0.9300	0.0485	0.5072	3.7565	1.9672	100.84	107.54	72.34	0.062
6	0.5636	0.0233	0.9303	0.0250	0.5460	3.7580	2.1179	100.77	110.21	72.32	0.062
7	******	0.0014	0.9306	0.0015	******	3.7517	2.6741	100.33	******	72.14	0.062

TABLE 49 - PCD DATA FOR 20/30 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9297	0.0000	*******	3.764	*******	******
2	******	0.0000	0.9297	0.0000	*******	4.391	*******	******
3	******	0.0000	0.9297	0.0000	*******	4.823	*******	******
4	******	0.0000	0.9300	0.0000	*******	5.356	*******	******
5	******	0.0000	0.9300	0.0000	*******	5.724	*******	******
6	******	0.0000	0.9303	0.0000	*******	5.876	*******	******
7	******	0.0000	0.9306	0.0000	*******	******	*******	******



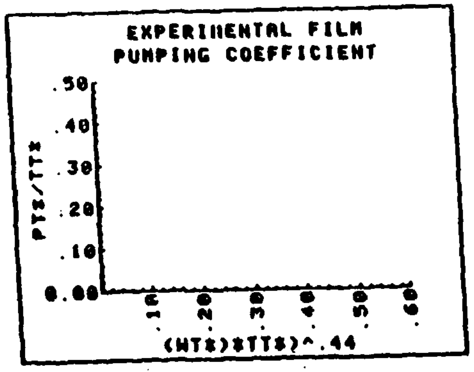


TABLE 40.1 - PCD DATA (CONT) FOR 20/30 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 27 AUG 81
DATA TAKEN BY: C.C DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/10 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 22.5 [DEG]
ROTATION ANGLE: 10 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM. PRESSURE: 29.83 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	56.0	111.0	71.0	4.35	2.78	0.00	0.000	*******
2	0.71	22.1	56.0	111.0	71.0	4.95	1.95	0.00	12.566	*******
3	0.70	22.0	56.0	111.0	71.0	5.40	1.39	0.00	25.133	*******
4	0.71	22.2	56.0	111.0	71.0	6.05	0.79	0.00	50.265	*******
5	0.71	22.1	57.2	111.0	72.0	6.50	0.30	0.00	100.531	*******
6	0.71	22.1	57.0	111.2	71.0	6.65	0.16	0.00	150.796	*******
7	0.70	22.1	57.6	111.4	72.0	6.80	0.01	0.00	*******	*******

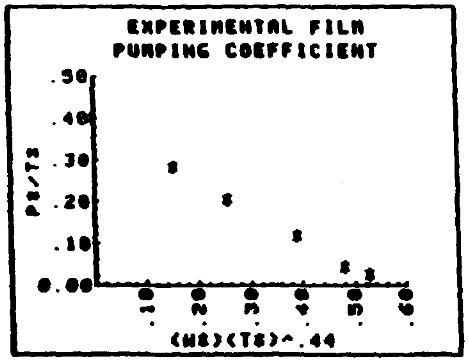
SECONDARY BOX

N	W*	P*	T*	P*/T*	W*T^.44	WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3742	0.9313	0.4018	0.0000	3.7578	0.0000	102.78	73.12	73.12	0.062
2	0.1590	0.2648	0.9313	0.2843	0.1541	3.7494	0.5960	102.00	83.53	72.81	0.062
3	0.2690	0.1901	0.9313	0.2041	0.2608	3.7409	1.0065	101.33	90.65	72.54	0.062
4	0.4030	0.1074	0.9313	0.1153	0.3914	3.7578	1.5175	101.89	100.07	72.76	0.062
5	0.4989	0.0411	0.9317	0.0441	0.4836	3.7479	1.8700	101.19	106.15	72.48	0.062
6	0.5466	0.0219	0.9310	0.0235	0.5296	3.7486	2.0480	101.22	109.37	72.50	0.062
7	******	0.0014	0.9310	0.0015	******	3.7465	2.6659	101.11	******	72.45	0.062

TABLE 50 - PCD DATA FOR 22.5/10 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9313	0.0000	*******	3.750	*******	******
2	******	0.0000	0.9313	0.0000	*******	4.345	*******	******
3	******	0.0000	0.9313	6.0000	*******	4.747	*******	******
4	******	0.0000	0.9313	0.0000	*******	5.275	*******	******
5	******	0.0000	0.9317	0.0000	*******	5.610	*******	******
6	******	0.0000	0.9310	0.0000	*******	5.797	*******	******
7	******	0.0000	0.9310	0.0000	*******	******	*******	******



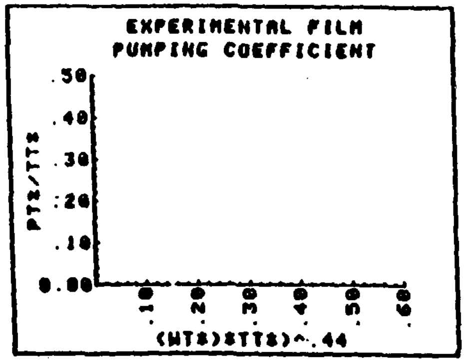


TABLE 50.1 - PCD DATA (CONT) FOR 22.5/10 NOZZLES WITH L/D=1.25 STACK

DATA TAKEN ON: 27 AUG 81
DATA TAKEN BY: C.C. DAVIS

NOZZLE AM/AP AREA RATIO: 2.50

COMMENTS:
22.5 TILT/20 ROTATION/PCD

MIXING STACK INFORMATION:
LENGTH: 14.63 [IN]
DIAMETER: 11.70 [IN]
L/D RATIO: 1.25
S/D RATIO: 0.50

PRIMARY NOZZLE INFORMATION:
TILT ANGLE: 22.5 [DEG]
ROTATION ANGLE: 20 [DEG]
AREA PER NOZZLE: 10.752 [IN2]
NUMBER OF NOZZLES: 4

MISCELLANEOUS INFORMATION:
ORIFICE DIAMETER: 6.902 [IN]
ORIFICE BETA: 0.497
UPTAKE AREA: 107.510 [IN2]
ATM PRESSURE: 29.83 [INHG]

N	POR	DPOR	TOR	TUPT	TAMB	PUPT	PSEC	PTER	SECONDARY AREA	TERTIARY AREA
RUN	IN OF H2O		DEGREES F			IN OF H2O			SQUARE INCHES	SQUARE INCHES
1	0.71	22.2	56.6	111.0	72.0	3.90	2.94	0.00	0.000	*******
2	0.70	22.0	57.0	111.0	72.0	4.65	2.11	0.00	12.566	*******
3	0.70	21.9	56.6	110.0	71.0	5.20	1.50	0.00	25.133	*******
4	0.70	22.1	56.0	110.6	72.0	5.05	0.84	0.00	50.265	*******
5	0.70	22.0	56.6	110.6	72.2	6.35	0.31	0.00	100.531	*******
6	0.71	22.2	56.0	110.6	72.0	6.50	0.16	0.00	150.796	*******
7	0.71	22.2	57.0	110.0	72.0	6.65	0.01	0.00	*******	*******

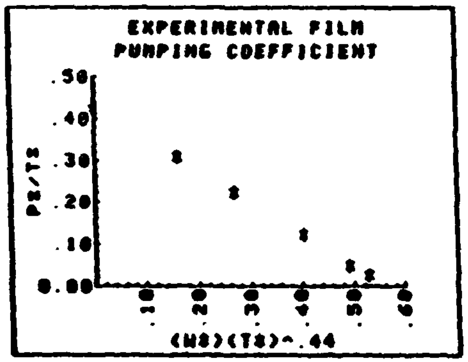
SECONDARY BOX

N	W*	P*	T*	P*/T* W*T^.44		WP	WS	UP	UM	UUPT	UPT MACH
RUN						LBM/SEC	LBM/SEC	FT/SEC	FT/SEC	FT/SEC	
1	0.0000	0.3954	0.9317	0.4244	0.0000	3.7586	0.0000	102.09	73.16	73.16	0.062
2	0.1657	0.2878	0.9317	0.3089	0.1607	3.7402	0.6199	101.62	83.81	72.66	0.062
3	0.2801	0.2060	0.9316	0.2212	0.2715	3.7331	1.0456	100.94	91.20	72.38	0.062
4	0.4169	0.1147	0.9323	0.1230	0.4043	3.7523	1.5645	101.51	100.70	72.61	0.062
5	0.5079	0.0427	0.9327	0.0458	0.4926	3.7416	1.9005	100.76	106.54	72.31	0.062
6	0.5451	0.0219	0.9323	0.0234	0.5286	3.7570	2.0485	101.48	109.47	72.60	0.062
7	******	0.0014	0.9320	0.0015	******	3.7571	2.6659	101.44	******	72.50	0.062

TABLE 51 - PCD DATA FOR 22.5/20 NOZZLES WITH L/D=1.25 STACK

TERTIARY BOX

N	WT*	PT*	TT*	PT*/TT*	WT*TT^.44	WM	WT	UE
RUN						LBM/SEC	LBM/SEC	FT/SEC
1	******	0.0000	0.9317	0.0000	*******	3.759	*******	******
2	******	0.0000	0.9317	0.0000	*******	4.360	*******	******
3	******	0.0000	0.9316	0.0000	*******	4.779	*******	******
4	******	0.0000	0.9323	0.0000	*******	5.317	*******	******
5	******	0.0000	0.9327	0.0000	*******	5.642	*******	******
6	******	0.0000	0.9323	0.0000	*******	5.806	*******	******
7	******	0.0000	0.9320	0.0000	*******	******	*******	******



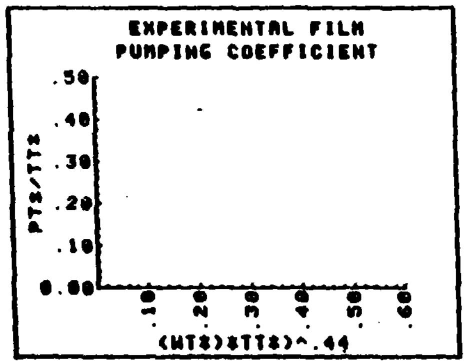


TABLE 51.1 - PCD DATA (CONT) FOR 22.5/20 NOZZLES WITH L/D=1.25 STACK

APPENDIX: A

ONE-DIMENSIONAL ANALYSIS OF A SIMPLE EDUCTOR

This thesis is a further extension of the work conducted by Ellin, Moss, Lemke and Staehli, Shaw, and Ryan [Ref. 1,2, 3,4, and 5] and uses the same one-dimensional analysis of a simple eductor syste. Similarity between the basic geome-tries tested by previous researchers was maintained to cor-relate data and preserve the error analysis conducted by Ellin. The dimensionless parameters controlling the flow phenomena used previously were also used in the present research along with the basic means of data analysis and pre-sentation. Dynamic similarity was maintained by using Mach number similarity to establish the gas eductor model's primary flow rate.

Although the analysis presented here is for an eductor model with only primary and secondary air flows, the basic discussion applies as well to systems with primary, second-ary, and tertiary flows. Systems with tertiary and film or wall cooling air flows have been non-dimensionalized with the same base parameters as the secondary air flow and have been calculated using the same non-dimensional analysis. This allows easier comparison or tabulated and graphic results. Parameters pertaining to the secondary systems are subscripted with an "s" and those relating to the tertiary box are sub-scripted with a "t".

A. MODELING TECHNIQUE

Dynamic similarity between the models tested and an actual prototype was maintained by using the same primary air flow Mach number. For the primary air flow Mach number used (0.064), and based on the average flow properties within the mixing stack and the hydraulic diameter of the mixing stack, the air flow through the eductor system is turbulent ($Re > 10^5$). As a consequence of this, momentum exchange is predominant over shear interaction, and the kinetic and internal energy terms are more influential on the flow than are viscous forces. It can also be shown that the Mach number represents the ratio of kinetic energy of a flow to its internal energy and is, therefore, a more significant parameter than the Reynolds number in describing the primary flow through the uptakes.

B. ONE-DIMENSIONAL ANALYSIS OF A SIMPLE EDUCTOR

The theoretical analysis of an eductor may be approached in two ways. One method attempts to analyse the details of the mixing process of the primary and secondary air streams as it takes place inside the mixing stack. This requires an interpretation of the mixing phenomemon which, when applied to a multiple nozzle system, becomes extremely complex. The other method, which was chosen here, analyzes the overall performance of the eductor system and is not concerned with the actual mixing process. The one-dimensional analysis based on a single primary nozzle exhausting into a mixing stack, is

shown in Figure A-1. To avoid repetition with previous reports, only the main parameters and assumption will be represented here. A complete derivation of analysis used can be found in Reference [1] and [9]. The one-dimensional flow analysis of the simple eductor system described depends on the simultaneous solution of the continuity, momentum and energy equations coupled with the equation of state, all compatible with specific boundary conditions.

The idealizations made for simplifying the analysis are as follows:

1. The flow is steady state and incompressible.
2. Adiabatic flow exists throughout the eductor with isentropic flow of the secondary stream from the plenum (at section 0) to the throat or entrance of the mixing stack (at section 1) and irreversible adiabatic mixing of the primary and secondary streams occurs in the mixing stack (between sections 1 and 2).
3. The static pressure across the flow at the entrance and exit planes of the mixing-tube (at sections 1 and 2) is uniform.
4. At the mixing-stack entrance (section 1) the primary flow velocity U_p and temperature T_p are uniform across the primary stream, and the secondary flow velocity U_s and temperature T_s are uniform across the secondary stream, but U_p does not equal U_s, and T_p does not equal T_s.

5. Incomplete mixing of the primary and secondary streams in the mixing stack is accounted for by the use of a non-dimensional momentum correction factor K_m which relates the actual momentum rate to the pseudo-rate based on the bulk-average velocity and density and by the use of a non-dimensional kinetic energy correction factor K_e which relates the actual kinetic energy rate to the pseudo-rate based on the bulk-average velocity and density.
6. Both gas flows behave as perfect gases.
7. Flow potential energy position changes are negligible.
8. Pressure changes P_{s0} to P_{s1} and P_1 to P_a are small relative to the static pressure so that the gas density is essentially dependent upon temperature (and atmospheric pressure).
9. Wall friction in the mixing stack is accounted for with the conventional pipe friction factor term based on the bulk-average flow velocity U_m and the mixing stack wall area A_w.

The following parameters, defined here for clarity, will be used in the following development.

$\frac{A_p}{A_m}$ area ratio of primary flow area to mixing stack cross sectional area

$\frac{A_w}{A_m}$ area ratio of wall friction area to mixing stack cross sectional area

k_p momentum correction factor for primary mixing

k_m momentum correction factor for mixed flow

f wall friction factor

Based on the continuity equation, the conservation of mass principle for steady flow yields

$$W_m = W_p + W_s + W_t \tag{1}$$

where

$$\begin{aligned} W_p &= \rho_p U_p A_p \\ W_s &= \rho_s U_s A_s \\ W_t &= \rho_t U_t A_t \\ W_m &= \rho_m U_m A_m \end{aligned} \tag{1a}$$

All of the above velocity and density terms, with the exception of ρ_m and U_m, are defined without ambiguity by the virtue of idealizations (3) and (4) above. Combining equations (1) and (1a) above, the bulk average velocity at the exit plane of the mixing stack becomes

$$U_m = \frac{W_s + W_t + W_p}{\rho_m A_m} \tag{1b}$$

where A_m is fixed by the geometric configuration and

$$\rho_m = \frac{P_a}{RT_m} \tag{2}$$

where T_m is calculated as the bulk average temperature from the energy equation (9) below. The momentum equation stems from Newton's second and third laws of motion and is the conventional force and momentum-rate balance in fluid mechanics.

$$K_p\left(\frac{W_pU_p}{g_c}\right) + \left(\frac{W_sU_s}{g_c}\right) + \left(\frac{W_tU_t}{g_c}\right) + P_1A_1 = K_m\left(\frac{W_mU_m}{g_c}\right) + P_2A_2 + F_{fr} \tag{3}$$

Note the introduction of idealizations (3) and (5). To account for a possible non-uniform velocity profiles across the primary nozzle exit, the momentum correction factor K_p is introduced here. It is defined in a manner similar to that of K_m and by idealization (4), supported by work conducted by Moss, it is set equal to unity. K_p is carried through this analysis only to illustrate its effect on the final result. The momentum correction factor for the mixing stack exit is defined by the relation

$$K_m = \frac{1}{W_mU_m}\int_0^{A_m} U_m^{\,2}\,\rho_2 dA \tag{4}$$

where U_m is evaluated as the bulk-average velocity from equation (1b). The wall skin friction force F_{fr} can be related to the flow stream velocity by

$$F_{fr} = f\,A_w\left(\frac{U_m^2 \rho_m}{2g_c}\right) \tag{5}$$

using idealization (9). As a reasonably good approximation for turbulent flow, the friction factor may be calculated from the Reynolds number

$$f = 0.046(Re_m)^{-0.2} \tag{6}$$

Applying the conservation of energy principle to the steady flow system in the mixing stack between the entrance and exit planes,

$$W_p\left(h_p + \frac{U_p^2}{2g_c}\right) + W_s\left(h_s + \frac{U_s^2}{2g_c}\right) + W_t\left(h_t + \frac{U_t^2}{2g_c}\right)$$

$$= W_m\left(h_m + K_e\frac{U_m^2}{2g_c}\right) \tag{7}$$

neglecting potential energy of position changes (idealization 7). Note the introduction of the kinetic energy correction factor K_e, which is defined by the relation

$$K_e = \frac{1}{W_m U_m^2} \int_0^{A_m} U_2^{\ 3} \rho_2 dA \tag{8}$$

It may be demonstrated that for the purpose of evaluating the mixed mean flow temperature T_m, the kinetic energy terms may be neglected to yield

$$h_m = \frac{W_p}{W_m} h_p + \frac{W_s}{W_m} h_s + \frac{W_t}{W_m} h_t \tag{9}$$

where $T_m = \phi(h_m)$ only, with the idealization (6).

The energy equation for the isentropic flow of the secondary air from the plenum to the entrance of the mixing stack may be shown to reduce to

$$\frac{P_o - P_s}{\rho_s} = \frac{U_s^{\ 2}}{2g_s} \tag{10}$$

similarly, the energy equation for the tertiary air flow reduces to

$$\frac{P_o - P_t}{\rho_t} = \frac{U_t^{\ 2}}{2g_c}$$

The previous equations may be combined to yield the vacuum produced by the eductor action in either the secondary or tertiary air plenums. For the secondary air plenum, the vacuum produced is

$$P_a - P_{os} = \frac{1}{g_c A_m}\left(K_p \frac{W_p^{\,2}}{A_p \rho_p} + \frac{W_s^{\,2}}{A_s \rho_s}\left(1 - \frac{1}{2}\frac{A_m}{A_s}\right) - \frac{W_m^{\,2}}{A_m \rho_m}\left(K_m + \frac{f}{2}\frac{A_w}{A_m}\right)\right) \tag{11}$$

where it is understood that A_p and ρ_s apply to the secondary flow at this same section, and A_m and W_m apply to the mixed flow at the exit of the mixing stack system. P_a is atmospheric pressure, and is equal to the pressure at the exit of the mixing stack. A_w is the area of the inside wall of the mixing stack.

For the tertiary air plenum, the vacuum produced is

$$P_a - P_{ot} = \frac{1}{g_c A_m}\left(k_p \frac{(W_p + W_s)^2}{(A_p \rho_p + A_s)} + \frac{W_t^{\,2}}{A_t \rho_t}\left(1 - \frac{1}{2}\frac{A_m}{A_t}\right)\right.$$

$$\left. = \frac{W_m^{\,2}}{A_m \rho_m}\left(K_m + \frac{f}{2}\frac{A_w}{A_m}\right)\right) \tag{11a}$$

where the primary flow now consists of both the primary and secondary air flows.

C. NON-DIMENSIONAL FORM OF THE SIMPLE EDUCTOR EQUATION

In order to provide the criteria of similarity of flows with geometric similarity, the non-dimensional parameters which govern the flow must be determined. The means chosen for determining these parameters was to normalize equations (11) and (11a) with the following dimensionless groupings.

$$P^* = \frac{\dfrac{P_a - P_{os}}{\rho_s}}{\dfrac{U_p^2}{2g_c}}$$

a pressure coefficient which compares the pumped head $P_a - P_{os}$ for the secondary flow to the driving head $\dfrac{U_p^2}{2g_c}$ of the primary flow

$$PT^* = \frac{\dfrac{P_a - P_{ot}}{\rho_t}}{\dfrac{U_p^2}{2g_c}}$$

a pressure coefficient which compares the pumped head $P_a - P_{ot}$ for the tertiary flow to the driving head $\dfrac{U_p^2}{2g_c}$ of the primary flow

$$W^* = \frac{W_s}{W_p}$$

a flow rate ratio, secondary to primary mass flow rate

$$WT^* = \frac{W_t}{W_p}$$

a flow rate ratio, tertiary to primary mass flow rate

$$T^* = \frac{T_s}{T_p}$$

an absolute temperature ratio, secondary to primary

$$TT^* = \frac{T_t}{T_p}$$

an absolute temperature ratio, tertiary to primary

$$\rho_s^* = \frac{\rho_s}{\rho_p}$$

a flow density ratio of the secondary to primary flows. (Note that since the fluids are considered perfect gases,

$$\rho_s^* = \frac{T_p}{T_s} = \frac{1}{T_s^*}$$

$$\rho_t^* = \frac{\rho_t}{\rho_p}$$

a flow density ratio of the tertiary or fil, cooling flow to primary flows. (Note that since the fluids are considered perfect gases,

$$\rho_t^* = \frac{T_p}{T_t} = \frac{1}{T_t^*}$$

$$A_s^* = \frac{A_s}{A_p}$$

an area ratio of secondary flow area to primary flow area

$$A_t^* = \frac{A_t}{A_p}$$

an area ratio of tertiary flow area to primary flow area

With these non-dimensional groupings, equations (11) and (11a) can be rewritten in dimensionless form. Since both equations follow the same format, only the results for the secondary air plenum will be presented here.

$$\frac{P^*}{T^*} = 2\,\frac{A_p}{A_m}\left((K_p - \frac{A_p}{A_m}\beta) - W^*(K_p + T^*)\,\frac{A_p}{A_m}\beta\right.$$

$$\left. + W^{*2}T^*\left(\frac{1}{A^*}(K_p - \frac{A_m}{2A^*A_p}) - \frac{A_p}{A_m}\beta\right)\right) \qquad (12)$$

where

$$\beta = K_m + \frac{f}{2}\frac{A_w}{A_m}.$$

This may be rewritten as

$$\frac{P^*}{T^*} = C_1 + C_2W^*(T + 1) + C_3W^{*2}T^* \qquad (13)$$

where

$$C_1 = 2\,\frac{A_p}{A_m}(K_p - \frac{A_p}{A_m}\beta),$$

$$C_2 = -\left(\frac{A_p}{A_n}\right)^2 \beta, \quad \text{and}$$

$$C_3 = 2\,\frac{A_p}{A_m}\left(\frac{1}{A^*} - \frac{A_m}{2A^*A_p}\beta - \frac{A_p}{A_m}\beta\right).$$

As can be seen from equation (13),

$$P^* = F(W^*, T^*) .$$

The additional dimensionless quantities listed below were used to correlate the static pressure distribution down the length of the mixing stack.

$$PMS^* = \frac{\frac{PMS}{\rho_s}}{\frac{U_p^2}{2g_c}}$$

a pressure coefficient which compares the pumping head $\frac{PMS}{\rho_s}$ for the secondary flow to the driving head $\frac{U_p^2}{2g_c}$ of the primary flow,

where PMS = static pressure along the mixing stack length

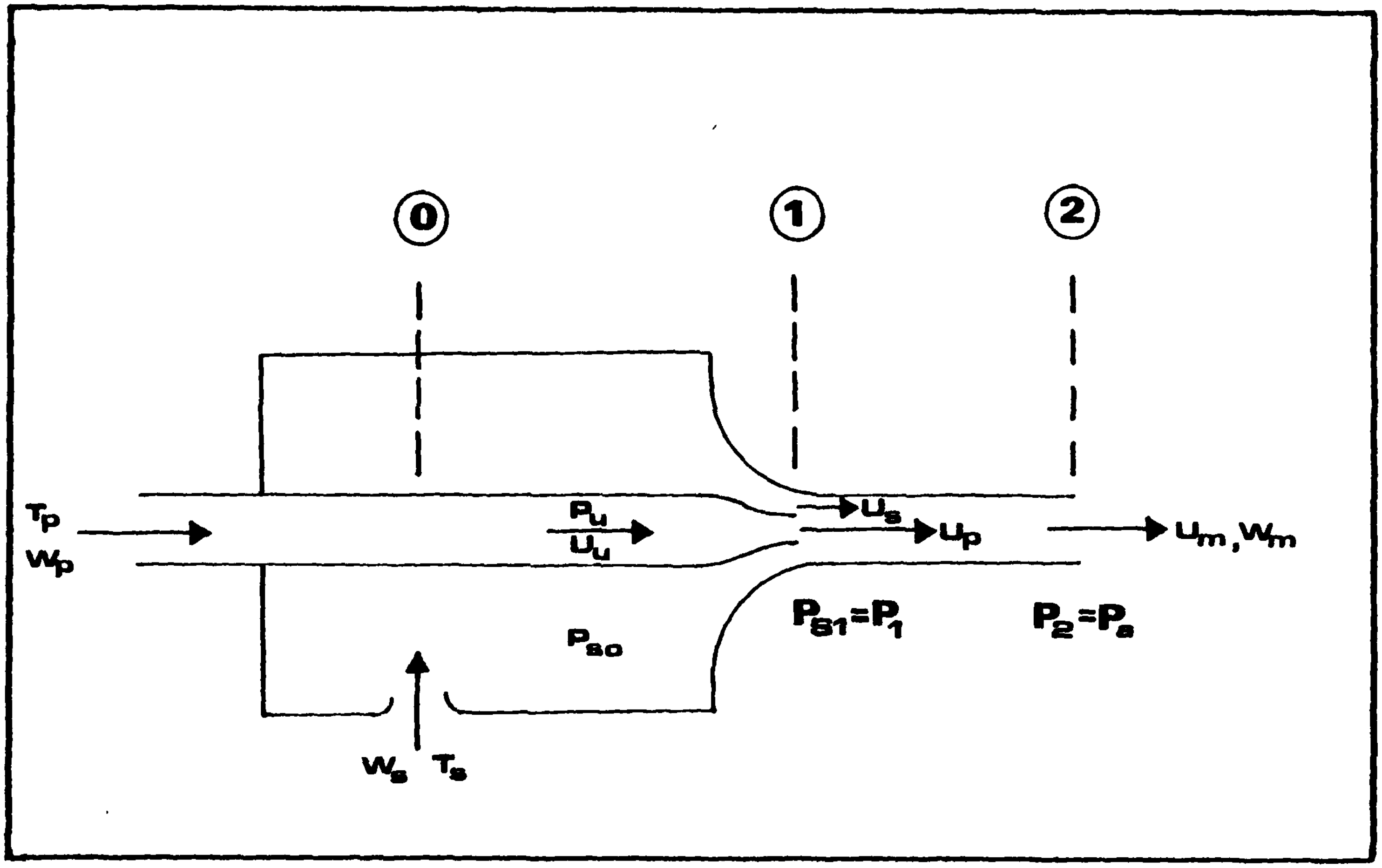


FIGURE A-1. SIMPLE SINGLE NOZZLE EDUCTOR SYSTEM

APPENDIX: B

FORMULAE

Presented here are the formulas used to obtain the primary and secondary mass flow rates. According to the ASME primary Test Code [Ref. 8], the general equation for mass flow rate appearing in equation (a)

$$W(\text{lbm/sec}) = (0.12705)\ K\ A\ Y\ F_a\ (\rho\ \Delta P)^{0.5} \qquad \text{(a)}$$

may be used with flow nozzles and square edge orifices provided the flow is subsonic. In the above equation, K (dimensionless) represents the flow coefficient for the metering device and is defined as $K = C(1 - \beta^4)^{-0.5}$ where C is the coefficient of discharge and β is the ratio of throat to inlet diameters; $A(in^2)$ is the total cross sectional area of the metering device; Y (dimensionless) is the expansion factor for the flow; F_a (dimensionless) is the area thermal expansion factor; ρ (lbm/ft^3) is the flow mass density; and ΔP (inches H_2O) is the differential pressure across the metering device. Each of these quantities are evaluated, according to the guidelines set forth in Reference [8], for the specific type of flow measuring device used.

Using a square edge orifice for measurement of the primary mass flow rate, the quantities in equation (a) are defined as follows:

1. The flow coefficient K is 0.62 based on a β of 0.502 and a constant coefficient of discharge over the range of flows considered of 0.60.
2. The orifice area is 37.4145 in^2.
3. Corresponding to the range of pressure ratios encountered across the orifice, the expansion factor Y is 01.8.
4. Since the temperature of the metered air is nearly ambient temperature, thermal expansion factor is essentially 1.0.
5. The primary air mass density ρ_{or} is calculated using the perfect gas relationship with pressure and temperature evaluated upstream of the orifice.

Substituting these values into equation (a) yields

$$W_p \text{ (lbm/sec)} = (2.88455)\ (\rho_{or}\Delta P_{or})^{0.5} \qquad \text{(b)}$$

The secondary mass flow rate is measured using long radius flow nozzles for which case the quantities in equation (a) becomes:

1. For a flow nozzle installed in a plenum, β is approximately zero in which case the flow coefficient is approximately equal to the coefficient of discharge. For the range of secondary flows encountered, the flow coefficient becomes 0.98.
2. A is the sum of the throat areas of the flow nozzles in use (in^2).

3. Since the pressure ratios across the flow nozzles are very close to unity, the expansion coefficient Y is 1.0.

4. Since the temperature of the metered air is nearly ambient temperature, the thermal expansion factor is essentially 1.0.

5. The secondary air mass density ρ_s is evaluated using the perfect gas relationship at ambient conditions.

Substituting these values into equation (a) yields the equation for the secondary mass flow rate measured using long radius flow nozzles.

$$W_s \text{ (lbm/sec)} = 0.12451) A (\rho_s \Delta P_s)^{0.5} \qquad \text{(c)}$$

APPENDIX: C

UNCERTAINTY ANALYSIS

The determination of the uncertainities in the experimentally determined pressure coefficients, pumping coefficients, and velocity profiles was made using the methods described by Kline and McClintock [Ref. 10]. The basic uncertainty analysis for the cold flow eductor model test facility was conducted by Ellin [Ref. 1]. The uncertainties obtained by Ellin using the second order equation suggested by Kline and McClintock were applicable to the experimental work conducted during the present research and are listed in the following table.

UNCERTAINTY IN MEASURED VALUES

T_s	± 1 R
T_p	± 1 R
P_a	± 0.01 psia
ΔP	± 0.01 in. H_2O
P_V	± 0.01 in. H_2O
P_u	± 0.05 in. H_2O
ΔP_s (+)	± 0.01 in. H_2O
ΔP_t (**)	± 0.01 in. H_2O
P_{or}	± 0.01 in. H_2O
ΔP_{or}	± 0.20 in. H_2O
T_{or}	± 1 R

T_a	± 1 R
PT (***)	± 0.1 in. H_2O

UNCERTAINTY IN CALCULATED VALUES

$\frac{P^*}{T^*}$	1.9%
$W^*T^{*0.44}$	1.4%
V/V_{avg}	2.5%
(+)	The pressure differential across the secondary flow nozzles, P_s. is the major source of uncertainty in the pumping coefficennt.
(++)	The pressure differential across the tertiary flow nozzles, P_t, is the major source of uncertainty in the pumping coefficient.
(+++)	The measurement of the total pressure for the velocity profile is the major source of uncertainty in the velocity calculation.

APPENDIX: D

ASME FLOW METERING COMBINATION NUMBERS AND DATA SHEETS

The total cross-sectional area of the ASME long radius nozzles is one of the major inputs for determining the secondary air flow rate. Calculation of these areas as the nozzles are sequentially opened to the atmosphere can be difficult, time consuming, and possibly error prone. To increase accuracy while lowering the data acquisition time, past research was conducted using nozzle combination numbers to represent the areas involved.

Past combination numbers were determined by taking the diameters of the nozzles in use, squaring them, and then dividing by four. For example, if one-four inch and one-eight inch nozzle had been opened, $4^2 = 16$

$$8^2 = 64$$

$$16 + 64 = 80/4 = 20$$

The combination number, 20, is thus easily calculated and easier still to input into the reduction programs. When multiplied by PI, the area becomes 62.832 square inches.

This research deviated from this past practice by eliminating all calculations in the acquisition process. The combination numbers used for the data sheets and for computer data reduction entry made the flow metering area calculations still easier to use. A set of areas which gave the opt'mum plotting points for the pumping coefficient plots were

determined, and the number and type of nozzles to be opened for each run were added to the data sheets along with the corresponding combination number. These standard combinations proved effective and efficient during this investigation, and room was left on the data sheets for non-standard combinations should they be needed at a future data. The reduction program uses the actual areas in calculating the secondary air flow, and the pumping coefficient program "PCDSTORE" performs the combination number/area conversion. This was done to allow the older combination numbers to be used again by modifying the smaller, less complicated input program without having to modify the more complex reduction program if such a need should arise.

The reduced size listings of the various combination numbers and corresponding areas are given in Table D-1. Reduced size samples of the data acquisition sheets are provided in Figures D-1, D-2, and D-3. The reduction makes the combination numbers difficult to read under the headings CSEC and CTER for secondary and tertiary combination numbers respectively in Figure D-1, but the ease of use should be apparant.

ASME FLOW NOZZLE COMBINATIONS

NUMBER OF NOZZLES			AREA	COMBINATION NUMBER	
2 INCH	4 INCH	8 INCH	(SQ INCHES)	SECONDARY	TERTIARY
0	0	0	000.000	1	1
1	0	0	3.140	2	2
2	0	0	6.283	3	3
0	1	0	12.566	4	4
1	1	0	15.708	5	5
2	1	0	18.850	6	6
0	2	0	25.133	7	7
1	2	0	28.850	8	8
2	2	0	31.416	9	9
0	3	0	37.699	10	10
1	3	0	40.841	11	11
2	3	0	43.982	12	12
0	0	1	50.265	13	13
1	0	1	53.407	14	14
2	0	1	56.549	15	15
0	1	1	62.832	16	16
1	1	1	65.973	17	17
2	1	1	69.115	18	18
0	2	1	75.398	19	19
1	2	1	78.540	20	20
2	2	1	81.681	21	21
0	3	1	87.965	22	22
1	3	1	91.106	23	23
2	3	1	94.248	24	24
0	0	2	100.531	25	25
1	0	2	103.673	26	26
2	0	2	106.814	27	27
0	1	2	113.097	28	28
1	1	2	116.239	29	29
2	1	2	119.381	30	30
0	2	2	125.664	31	31
1	2	2	128.805	32	32

TABLE D-1 ASME FLOW METERING NOZZLE COMBINATION NUMBERS

ASME FLOW NOZZLE COMBINATIONS (CONTINUED)

NUMBER OF NOZZLES			AREA	COMBINATION NUMBER	
2 INCH	4 INCH	8 INCH	(SQ INCHES)	SECONDARY	TERTIARY
2	2	2	131.947	33	33
0	3	2	138.230	34	34
1	3	2	141.372	35	35
2	3	2	144.513	36	36
0	0	3	150.796	37	--
1	0	3	153.938	38	--
2	0	3	157.080	39	--
0	1	3	163.363	40	--
1	1	3	166.504	41	--
2	1	3	169.646	42	--
0	2	3	175.929	43	--
1	2	3	179.071	44	--
2	2	3	182.212	45	--
0	3	3	188.496	46	--
1	3	3	191,637	47	--
2	3	3	194.779	48	--
0	0	4	201.062	49	--
1	0	4	204.204	50	--
2	0	4	207.345	51	--
0	1	4	213.628	52	--
1	1	4	216.770	53	--
2	1	4	219.911	54	--
0	2	4	226.195	55	--
1	2	4	229.336	56	--
2	2	4	232.478	57	--
0	3	4	238.761	58	--
1	3	4	241.903	59	--
2	3	4	245.044	60	--
DOORS/NOZZLES OPEN			785.000	999	999

TABLE D-1 (CONTINUED)

PUMPING COEFFICIENT DATA

NOZZLE	
TILT ANGLE	(DEG)
ROTATION ANGLE	(DEG)
FLOW AREA	10.752 (IN^2)

MIXING STACK	
LENGTH	(IN)
DIAMETER	(IN)
L/D RATIO	
S/D RATIO	

ATMOSPHERIC PRESSURE (IN HG)	
START	STOP

AMBIENT TEMPERATURE	
START	STOP
(°F)	(°F)

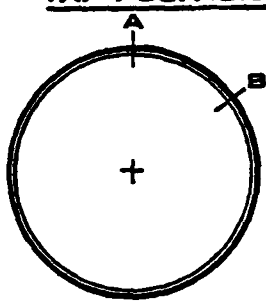
RUN	POR	DPOR	TOR TCN2	TUPT TCN 3	PUPT	PSEC SCN1-2	PTER SCN 3	CSEC					CTER				
								2	4	8	S		2	4	8	S	
1								0	0	0	1						
2								0	1	0	4						
3								0	2	0	7						
4								0	0	1	13						
5								0	0	2	25						
6								0	0	3	37						
7								O	P	E	N						
8																	
9																	
10																	

DATE		RUN		DATA RECORDER	

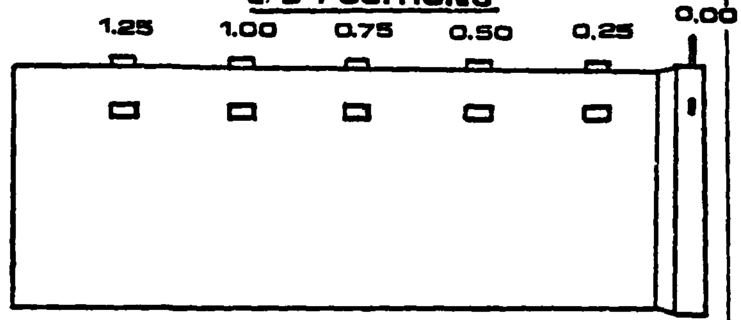
FIGURE D-1 SAMPLE PUMPING COEFFICIENT DATA SHEET

MIXING STACK DATA

TAP POSITIONS



L/D POSITIONS



L/D	PRESSURE TAP DATA			
	POSITION A		POSITION B	
POSITION	PRESSURE	ROTATION	PRESSURE	ROTATION
0.00	6		7	
0.25	8		9	
0.50	10		11	
0.75	12		13	
1.00	14		15	
1.25	16		17	
1.50	18		19	
1.75				
2.00				
2.25				
2.50				

DATE		RUN	

DATA RECORDER	

FIGURE D-2 SAMPLE MIXING STACK DATA SHEET

VELOCITY TRAVERSE DATA

ROTATION ANGLE | °

HORIZONTAL		
POSITION		PRESSURE
STD (IN)	NON-STD	(IN H_2O)
.0		
.2		
.4		
.6		
.8		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0		
8.5		
9.0		
9.5		
10.0		
10.5		
11.0		
11.2		
11.4		
11.6		
11.8		
12.0		

DIAGONAL		
POSITION		PRESSURE
STD (IN)	NON-STD	(IN H_2O)
.0		
.2		
.4		
.6		
.8		
1.0		
1.5		
2.0		
2.5		
3.0		
3.5		
4.0		
4.5		
5.0		
5.5		
6.0		
6.5		
7.0		
7.5		
8.0		
8.5		
9.0		
9.5		
10.0		
10.5		
11.0		
11.2		
11.4		
11.6		
11.8		
12.0		

DATE | RUN

FIGURE D-3 SAMPLE VELOCITY TRAVERSE DATA SHEET

APPENDIX: E

COMPUTER PROGRAMMING INFORMATION

The research conducted by Ryan [Ref. 5] utilized a semi-automated data acquisition system in the later stages of eductor model testing. The system used the Hewlett Packard HP-85 computer which also served to reduce the data and to plot the results for more detailed analysis. The data input, reduction, and plot programs were designed for the eductor geometries used by Shaw and Ryan in their investigations. With the introduction of the angled nozzles and straight mixing stack, the programs written by Ryan no longer applied. Had more research time been available, the equipment suggested by Ryan to further automate the data acquisition could have been obtained and the programs written for the new geometries. In the configuration and state of automation available at the start of the present research, the semi-automatic data acquisition system actually would have taken longer to acquire the same amount of data that could be taken manually. The decision was reached to place the system in a standby status and to rewrite the necessary programs for the angled nozzles with straight mixing stack. Ryan's programs were left intact and are available on floppy disc Volume: DLRYAN should research be directed toward the symmetric concealment plug concept.

A. PROGRAMMING CONCEPTS

The programs written for the angled nozzles and straight mixing stack were designed to be versatile, have room for growth, and to anticipate immediate future needs. As such, they were written for full secondary and tertiary flow data reduction, plotting, and comparison vice to fulfill just the secondary data reduction and plotting needed in this research. The programs were written to maximize man-machine interfacing. Operators with little skill in the HP Basic Language used should have no problems entering data, reducing the inputs, storing the outputs, and generating the numerous plots required for this particular research. Each program was designed to ask simple questions on the computer's display screen, give the possible answer of data input formats, and provide numerous data error correction techniques. The data sheets listed in Appendix D, Figures D-1, D-2, and D-3 were designed to further assist the data acquisition process by providing blanks or spaces in the same order that the particular programs would ask for data entry. The programs were written so that all data entry, reduction, and plotting routines were located on one floppy disc and the temporary and permanent data files were stored on another floppy disc. This feature was incorporated to allow future researchers to store their data on their own individual floppy disc, prevent filling the disc during a data run, and allow easier data comparison with past research files.

B. OPERATING PROCEDURES

Each program contains its own instructions. The programs are loaded by the LOAD command. For example, to load the program to store the pumping coefficient data, the operator would type in LOAD "PCDSTORE" and press the ENDLINE key. After the program is loaded, the operator could press the LIST key to see what capabilities are present. The operator could have also pressed the RUN key if the capabilities were already known. Once the program is running, the operator just has to make basic decisions and answer simple questions.

The programs are generally used in the following order and this sequence is strongly recommended:

PCDSTORE	Enters all of the header information/data for the pumping coefficients. It also converts combination numbers to actual metering flow nozzle areas.
MSDSTORE	Enters data for the mixing stack pressure and flow rotation distributions.
VTDSTORE	Enters data for the two velocity traverse profiles.
DRPSMS	Asks if mixing stack data and velocity traverse data are to be reduced, and it then runs for about 20 minutes reducing the data, placing the data into temporary files, printing about eight feet of output formatted for the thesis requirements, and includes up to six mini-plots for immediate comparison.
DATSTORE	Reads all of the data for the particular run, sorts out the data needed for graphical comparison, and then permanently stores the comparison data.

SECPLOT	Allows stored data retrieval or manual data input comparisons of secondary flow pumping coefficients with capability to add comments located by the same units used to graph the data.
TERPLOT	Identical to SECPLOT except it plots the tertiary pumping coefficient comparisons.
MSDPLOT	Identical to SECPLOT except it plots the mixing stack pressure distributions in many different data combinations.
ROTPLOT	Same type program as MSDPLOT but plots the rotation angle distributions.
VTDPLOT	Plots only stored velocity profile data which cannot be compared with other data since the velocities are not dimensionless. It does have the option to compare the horizontal and diagonal velocity profiles, and allows comments to be added like the other programs.
FIGCOM	Allows adding figure or table numbers to finished plots or tables, adding comments which may have been left out, and has the option of locating these inputs on the plots by manually entering X-Y coordinates in plotter units or by using the digitizing feature of the plotter.
INITIALIZE	Initializes new floppy discs for data storage with properly dimensional memory allocations for the six temporary input/output storage files. It has several safeguards to prevent accidental purging of valuable data.
AUXPLOT	Plots the pumping coefficients by nozzle tilt/rotation angles for the summary plots. It has only manual data entry capability but retains comment addition similar to the other programs.

The INITIALIZE program would only be used once per thesis as sufficient memory is available on one floppy disc to handle all the data that could be taken over a six month span. FIGCOM and AUXPLOT are used mainly after all of the plots have been analyzed and finished products and summaries are desired.

For the inexperienced operator, a listing of programs can be obtained by typing in CAT and pressing ENDLINE with the program storage disc in the DRIVE 0 slot on the HP 82901M Flexible Disc Drive. Data listings can be obtained by typing CAT".DRIVE1.D701" and pressing ENDLINE with the data disc the DRIVE 1 slot on the disc drive. Further operating instructions can be found in the various operating manuals.

C. DATA FILES

Data files for this research period as stored on floppy disc Volume:DRIVE1 which is disc number two in the research manual. The information is stored by date-time-group and run number. For example, data for the pumping coefficients (secondary and tertiary) for the fourth data run on 26 August 1981 would be stored as P2608814. To facilitate future comparisons with the data derived during this research period, the data available and the file numbers are listed in the Summary of Tabulated Data which can be found in Tables 1.1, 1.2, and 1.3.

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